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Tier 1 Closure Plan for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility at the INEEL

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April 2003

Prepared for the
U.S. Department of Energy
Idaho Operations Office

ABSTRACT

This Tier 1 Closure Plan is one of a suite of documents needed to demonstrate compliance with requirements to close the Tank Farm Facility closure at the Idaho Nuclear Technology and Engineering Center at the Idaho National Engineering and Environmental Laboratory. The Tier 1 Closure Plan describes the site background, closure actions, required performance objectives, and the analyses conducted to evaluate the closure actions. The Tier 1 Closure Plan defines and bounds the parameters of the proposed closure approach. The Tier 2 Closure Plan is being developed, which provides detailed closure information that is bounded by the Tier 1 Closure Plan parameters. In addition to the Tier 1 Closure Plan, DOE Order 435.1 also requires the development of a waste incidental to reprocessing determination, radiological performance assessment, and composite analysis to classify the waste, establish the closure activities, and analyze closure performance as presented in the Tier 1 Closure Plan, respectively.

This Tier 1 Closure Plan for the Tank Farm Facility includes all of the elements required by DOE. Through the use of the closure plan's performance objectives, long-term protection of the public and the environment is demonstrated. The analyses in the radiological performance assessment and the composite analysis supporting the Tier 1 Closure Plan are conservative and substantiated. The parameters as defined and bounded in this Tier 1 Closure Plan, and supported by the performance assessment and composite analysis results, provide strong evidence to support the approval of this plan and issuance of an *Authorization to Proceed*.

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EXECUTIVE SUMMARY

Under the terms of a 1992 Consent Order (and subsequent modifications) between the Idaho Department of Health and Welfare (currently the Idaho Department of Environmental Quality) and the Department of Energy (DOE), DOE must permanently cease use of the belowground tanks in its Tank Farm Facility (TFF) at the Idaho National Engineering and Environmental Laboratory (INEEL) or bring the tanks into compliance with secondary containment requirements for tanks that store hazardous waste as required by regulations implementing the (Idaho) Hazardous Waste Management Act (HWMA) and the Resource Conservation and Recovery Act (RCRA). The DOE is proposing to close the TFF tanks because high radiation fields and possible high radiation dose to workers would make compliance with secondary containment requirements impractical, and the tanks are no longer needed for waste storage.

The TFF is part of the INEEL's Idaho Nuclear Technology and Engineering Center (INTEC). The TFF includes 11 belowground 300,000-gal and 318,000-gal tanks (hereinafter referred to as 300,000-gal tanks and numbered WM-180 through WM-190) and four belowground 30,000-gal tanks (numbered WM-103 through WM-106). Built between 1955 and 1964, these tanks have stored liquid high-level waste (HLW) generated by spent nuclear fuel (SNF) reprocessing operations and sodium-bearing waste (SBW) from reprocessing operations and decontamination activities. The 300,000-gal tanks are active and are currently used to store SBW and newly-generated liquid waste from INTEC plant operations and decontamination activities. The 30,000-gal tanks were taken out of service in 1983 and the tanks were isolated from the rest of the TFF.

HLW and SBW are classified as mixed waste and are dually regulated by the Idaho Department of Environmental Quality for hazardous constituents and by DOE for radioactive constituents. Consequently, the TFF closure must comply with hazardous waste as well as radioactive waste closure requirements. The planned end state for the TFF is a deactivated HLW facility and a clean-closed HWMA/RCRA unit.

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Required Closure Documents

This Tier 1 Closure Plan is one of a suite of documents needed to demonstrate compliance with DOE requirements, as defined in DOE Order 435.1 and implemented through DOE Manual 435.1-1 and Guide 435.1-1. This closure plan defines and bounds the parameters of the proposed closure approach to ensure the long-term protection of the public and the environment from a deactivated HLW facility closure.

In addition to the Tier 1 Closure Plan, a waste incidental to reprocessing (WIR) determination, radiological performance assessment, and composite analysis are being submitted. Upon approval of the Tier 1 Closure Plan by DOE Headquarters, an *Authorization to Proceed* is issued and closure activities may begin. A Tier 2 Closure Plan will also be developed for each phase of the closure. The Tier 2 plans will provide detailed closure information that is bounded by the parameters contained in the Tier 1 Closure Plan.

To meet the requirements of HWMA/RCRA, clean closure of the TFF is being proposed rather than closure to landfill standards. It is planned that the proposed waste removal and decontamination activities designed to remove the radionuclides required by DOE Order 435.1 will also remove hazardous waste constituents to the clean-closure standards as required by HWMA/RCRA. The *Idaho Hazardous Waste Management Act/Resource Conservation and Recovery Act Closure Plan for the Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183* presents the objectives and compliance strategy to meet clean-closure requirements for Phase 1 of TFF closure. The remaining closure phases will be included in similar plans. The *Sampling and Analysis Plan for the Post-Decontamination Characterization of the WM-182 and WM-183 Tank Residuals* specifies the types and quality of data that will be collected during closure. The data quality objectives in this plan were prepared as required by DOE Order 435.1 using the process defined by the Environmental Protection Agency.

Closure Scope and Methodology

The TFF closure was designed to meet two major objectives: comply with DOE requirements and comply with HWMA/RCRA requirements. The closure boundary for the TFF is located at the valve boxes inside the TFF fence where process waste lines feeding or leaving the facility can be isolated. Lines outside of the isolation points will be left accessible for subsequent closure phases. As tanks are closed, they will be isolated from the rest of the TFF. The TFF closure does not include the contaminated soils surrounding the TFF, which will be remediated under the INEEL's Comprehensive Environmental Response, Compensation, and Liability Act Program.

The closure process for each tank involves site preparation, tank isolation, decontamination, and grouting. Site preparation includes establishing support structures at the site; designing and building specialized equipment, such as tank washing, grouting, and video monitoring equipment; and installing utilities. Tank isolation and decontamination activities include valve box decontamination; process line isolation; pipe encasement decontamination; vault sump decontamination; vessel off-gas system isolation; tank access and non-process waste line isolation; and tank decontamination.

As part of the first closure phase, Tanks WM-182 and WM-183 will be closed. In a process to be used in all closure phases, the steam jets in the tanks will be used to remove bulk liquid wastes. A tank washing system will be installed to decontaminate the tank walls and agitate the tank heels. The system is designed to remove contaminants from the tank walls and provide incidental pH adjustment of the residuals. Post-decontamination data from samples will be used to determine the effectiveness of decontamination activities and whether or not the residuals meet the performance objectives for facility closure. These data will also be used to demonstrate compliance with HWMA/RCRA clean-closure requirements.

After tank decontamination effectiveness has been determined, and when decisions for DOE closure and HWMA/RCRA closure have been made, final heel management and tank grouting will begin. Tank vaults will be isolated and

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final grouting of the tanks, vaults, and piping will be performed. Post-closure monitoring and institutional controls will be implemented as required.

Closure Schedule and Sequence

As required by the 1992 Consent Order (and subsequent modifications), DOE must cease use of Tanks WM-182, WM-183, WM-184, WM-185, and WM-186 by June 30, 2003, and the remaining tanks by December 31, 2012. Ceasing use of the tanks, as defined in the Consent Order, means that DOE must empty the tanks down to their heels (that is, the liquid level remaining in each tank must be lowered to the greatest extent possible by the use of existing transfer equipment).

Closure of the TFF will be performed in five phases, with Tanks WM-182 and WM-183 being closed first. The closure of these two tanks will serve as a proof-of-process demonstration of the waste removal, decontamination, and sampling techniques for closure of the remaining 300,000-gal tanks. Phase 2 will include Tanks WM-184, WM-185, and WM-186; Phase 3, the four 30,000-gal tanks (WM-103, WM-104, WM-105, and WM-106); Phase 4, Tanks WM-180 and WM–181; and Phase 5, Tanks WM-187, WM-188, WM-189, and WM-190.

Waste Incidental to Reprocessing Determination

DOE requires deactivated HLW facilities that have residual radioactive waste and are closed in accordance with an approved closure plan to meet WIR requirements. The WIR determination process allows certain waste streams produced during HLW generation to be managed as low-level waste (LLW) or transuranic (TRU) waste if certain criteria are met. Residual radioactive material remaining in a deactivated HLW facility (such as the TFF) is considered HLW unless the material is determined, through the WIR determination process, to be LLW or TRU waste. This process ensures that waste is classified properly and that DOE manages and disposes of these waste streams within its regulatory authority. For the TFF, the WIR determination process has demonstrated that the residual radioactive waste can be managed as LLW and that the TFF may be closed as a deactivated HLW facility.

Radiological Performance Assessment

The performance assessment is a systematic analysis to demonstrate that the residual radioactive waste meets applicable performance objectives. The analysis estimates the radiation dose to humans and compares the estimates to a set of performance objectives specified by DOE Manual 435.1-1.

The performance assessment for the TFF modeled current data to predict the performance of the closed TFF over a 1,000-yr period. The point of compliance is the point of highest projected dose or concentration beyond a 300-ft (100-m) zone surrounding the waste. The TFF performance assessment considered the risk to two populations: a hypothetical member of the general public and a hypothetical intruder. Two time periods were used in the assessment: the institutional control period (assumed to be 100 yr following TFF

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closure) and the post-institutional control period (1,000 yr after the institutional control period).

It was assumed that a hypothetical member of the public resides at the INEEL site boundary during the operational and institutional control periods. During the post-institutional control period, the hypothetical member of the public was assumed to reside at INTEC. This receptor was used to evaluate the all-pathways (including food chains), air pathway, and drinking water pathway doses. These doses were compared to performance objectives. The hypothetical inadvertent intruder receptor was assumed to inadvertently intrude onto the TFF after the institutional control period (100 yr). Two scenarios were evaluated (an acute drilling scenario and a chronic drilling scenario) both of which considered exposure during water well development. The results of the TFF performance assessment indicate compliance with the performance objectives, as follows:

Performance Objective	*Performance Assessment Result*
All-Pathways 25 mrem/yr	1.86 mrem/yr
Airborne Emissions excluding radon 10 mrem/yr	0.51 mrem/yr
Average Annual Radon Flux 20 pCi/m2/s	0.39 pCi/m^2/s
Protection of Groundwater 4 mrem/yr	0.77 mrem/yr
Acute Drilling Scenario 500 mrem	232 mrem at 100 yr
Chronic Post-Drilling Scenario 100 mrem/yr	91.1 mrem/yr at 100 yr

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Composite Analysis

The composite analysis identifies all sources of radioactive material in the ground at the INEEL that could contribute to the potential doses from the TFF closure. Various INEEL areas and sources external to the closure site were identified and assessed for inclusion in the composite analysis. The projected dose from the sources of radioactive material is compared with the DOE primary dose limit of 100 mrem/yr and with the 30-mrem/yr dose constraint within a 1,000-yr period.

The composite analysis results indicate that the DOE primary dose limit of 100 mrem/yr and the 30-mrem/yr dose constraint within a 1,000 yr period will not be exceeded. The maximum all-pathways dose to the INTEC receptor during the compliance period was 2.8 mrem/yr at INTEC; the maximum all-pathways dose to the RWMC receptor from the modeled sources was 1.8 mrem/yr during the compliance period. The analysis also showed that the combined dose from the sources included in the composite analysis and from doses at the Radioactive Waste Management Complex (RWMC) would be a maximum of 29.2 mrem/yr

over a 1,000 yr period, which is less that the 30 mrem/yr dose guideline. All dose projections are less than the 100 mrem/yr limit.

Conclusions

This Tier 1 Closure Plan for the INTEC TFF includes all of the elements required by DOE and demonstrates that long-term protection of the public and the environment from this closure is ensured. The analyses in the radiological performance assessment and the composite analysis supporting the Tier 1 Closure Plan are conservative and substantiated. The parameters as defined and bounded in this Tier 1 Closure Plan and supported by the performance assessment and composite analysis results provide strong evidence to support the approval of this plan and issuance of an *Authorization to Proceed*.

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ACRONYMS

ALARA	as low as reasonably achievable
ANL-W	Argonne National Laboratory-West
ARA	Auxiliary Reactor Area
ATP	authorization to proceed
CA	composite analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
D&D	decontamination and decommissioning
DEQ	Department of Environmental Quality
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
DQO	data quality objective
DUST–MS	Disposal Unit Source Term–Multiple Species
EA	Environmental Affairs
EDE	effective dose equivalent
EIS	environmental impact statement
EM	Environmental Management
EPA	Environmental Protection Agency
ER	Environmental Restoration
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Register
FS	feasibility study
FWS	Fish and Wildlife Service
HEPA	high-efficiency particulate air
HLLW	high-level liquid waste

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HLW	high-level waste
HWMA	Hazardous Waste Management Act
IDAPA	Idaho Administrative Procedures Act
IDHW	Idaho Department of Health and Welfare
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LLW	low-level waste
MCL	maximum contaminant level
MEI	maximally exposed individual
NEPA	National Environmental Protection Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NWCF	New Waste Calcining Facility
ORIGEN	Isotope Generation and Depletion Code Matrix Exponential Method
OU	operable unit
PA	performance assessment
PBF	Power Burst Facility
PCB	polychlorinated biphenyl
PE	professional engineer
PEW	process equipment waste
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
ROVER	Space Nuclear Propulsion Program
RWMC	Radioactive Waste Management Complex
SAP	sampling and analysis plan

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SAR	safety analysis report
SBW	sodium-bearing waste
SI	International System of Units (Le Systeme International D'Unites)
SNF	spent nuclear fuel
SRPA	Snake River Plain Aquifer
STP	Site Treatment Plan
TAN	Test Area North
TFF	Tank Farm Facility
TRA	Test Reactor Area
TRU	transuranic
TSCA	Toxic Substances Control Act
TSR	technical safety requirement
U.S.	United States
USC	United States Code
UCL	upper confidence limit
USGS	United States Geological Survey
VOG	vessel off-gas
WAG	waste area group
WCF	Waste Calcining Facility
WINCO	Westinghouse Idaho Nuclear Company
WIR	waste incidental to reprocessing
WROC	Waste Reduction Operations Complex

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NOMENCLATURE

Ac	actinium
Ag	silver
Am	americium
At	astatine
Ba	barium
Be	beryllium
Bi	bismuth
C	carbon
Cd	cadmium
Ce	cerium
Cf	californium
Cl	chlorine
Cm	curium
Co	cobalt
Cr	chromium
Cs	cesium
Eu	europium
Fe	iron
Fr	francium
Gd	gadolinium
H	hydrogen
Hg	mercury
Ho	holmium
HTO	tritiated water, occurs when a water molecule exchanges a hydrogen atom for a tritium atom
I	iodine

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In	indium
Kr	krypton
La	lanthanum
Nb	niobium
Nd	neodymium
Ni	nickel
Np	neptunium
Pa	protactinium
Pb	lead
Pd	palladium
Pm	promethium
Po	polonium
Pr	praseodymium
Pu	plutonium
Ra	radium
Rb	rubidium
Rh	rhodium
Rn	radon
Ru	ruthenium
Sb	antimony
Se	selenium
Sm	samarium
Sn	tin
Sr	strontium
Tc	technetium
Te	tellurium

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Th	thorium
Tl	thallium
Tm	thulium
U	uranium
Y	yttrium
Zr	zirconium

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Tier 1 Closure Plan for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility at the INEEL

1. INTRODUCTION

Under the terms of the 1992 Consent Order (and subsequent modifications) between the Idaho Department of Health and Welfare (IDHW)[a] and the Department of Energy Idaho Operations Office (DOE-ID) (IDHW 1992), DOE-ID must permanently cease use of belowground tanks at its Tank Farm Facility (TFF) at the Idaho National Engineering and Environmental Laboratory (INEEL) or bring the tanks into compliance with secondary containment requirements for tanks that store hazardous waste as set forth by Idaho Administrative Procedures Act (IDAPA) 58.01.05.009 (2002) (40 *Code of Federal Regulations* [CFR] 265.193 [2002]). DOE is proposing to close the TFF tanks because high radiation fields, and possible high radiation dose to workers, would make compliance with secondary containment requirements impractical. In addition, the need for such tanks is not evident after 2012.

The TFF is part of the INEEL's Idaho Nuclear Technology and Engineering Center (INTEC). INTEC was established by the Atomic Energy Commission to build, test, and operate various types of nuclear reactors and support facilities. The INEEL occupies 890 mi^2 (2,300 km^2)[b] of desert in southeast Idaho (see Figure 1-1). The TFF includes eleven belowground 300,000-gal and 318,000-gal tanks (hereinafter referred to in this plan as 300,000-gal tanks) and four 30,000-gal tanks. The tanks are situated at INTEC as shown in Figure 1-2. The 300,000-gal tanks are numbered WM-180 through WM-190; the 30,000-gal tanks are numbered WM-103 through WM-106. The second modification to the Consent Order specifies that DOE must cease use of Tanks WM-182, WM-183, WM-184, WM-185,[c] and WM-186 by June 30, 2003, and the remaining tanks by December 31, 2012 (IDHW 1998). Ceasing use of the tanks, as defined in the Consent Order, means that DOE-ID must empty the tanks down to their heels (that is, the liquid level remaining in each tank must be lowered to the greatest extent possible by the use of existing transfer equipment).

Built between 1955 and 1964, the TFF stored high-level liquid waste (HLLW) and other ancillary liquid wastes generated by spent nuclear fuel (SNF) reprocessing operations and decontamination wastes from reprocessing facilities. The 30,000-gal tanks were taken out of service in 1983, and the tank inlets were cut and capped (DOE-ID 2001a). The 300,000-gal tanks remain active and are currently used to store sodium-bearing waste (SBW)[d] and to receive newly-generated liquid waste from plant operations and decontamination activities. To meet the language of the Settlement Agreement

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a. On July 1, 2000, the Idaho legislature elevated the Division of Environmental Quality, a part of IDHW, to the Idaho Department of Environmental Quality (DEQ). DEQ now oversees the implementation of the Consent Order. As such, citations and references to Idaho Administrative Procedures Act (IDAPA) 16 Title 01 (under IDHW) are now IDAPA 58 Title 01 (under DEQ).

b. The measurements for this Tier 1 Closure Plan were originally made in U.S. customary units. Where conventional, the measurements are also shown in the International System of Units (SI) and the correct number of significant digits preserved. Flow rates and specifications have not been converted.

c. The Consent Order allows Tank WM-185 to be used as an emergency spare tank (IDHW 1998).

d. Sodium-bearing waste is a liquid mixed waste produced from the second and third cycles of spent nuclear fuel reprocessing and waste calcinations, liquid waste (from the INTEC closure activities) stored in the TFF, solids in the bottoms of the tanks, and trace contamination from first-cycle reprocessing extraction waste.

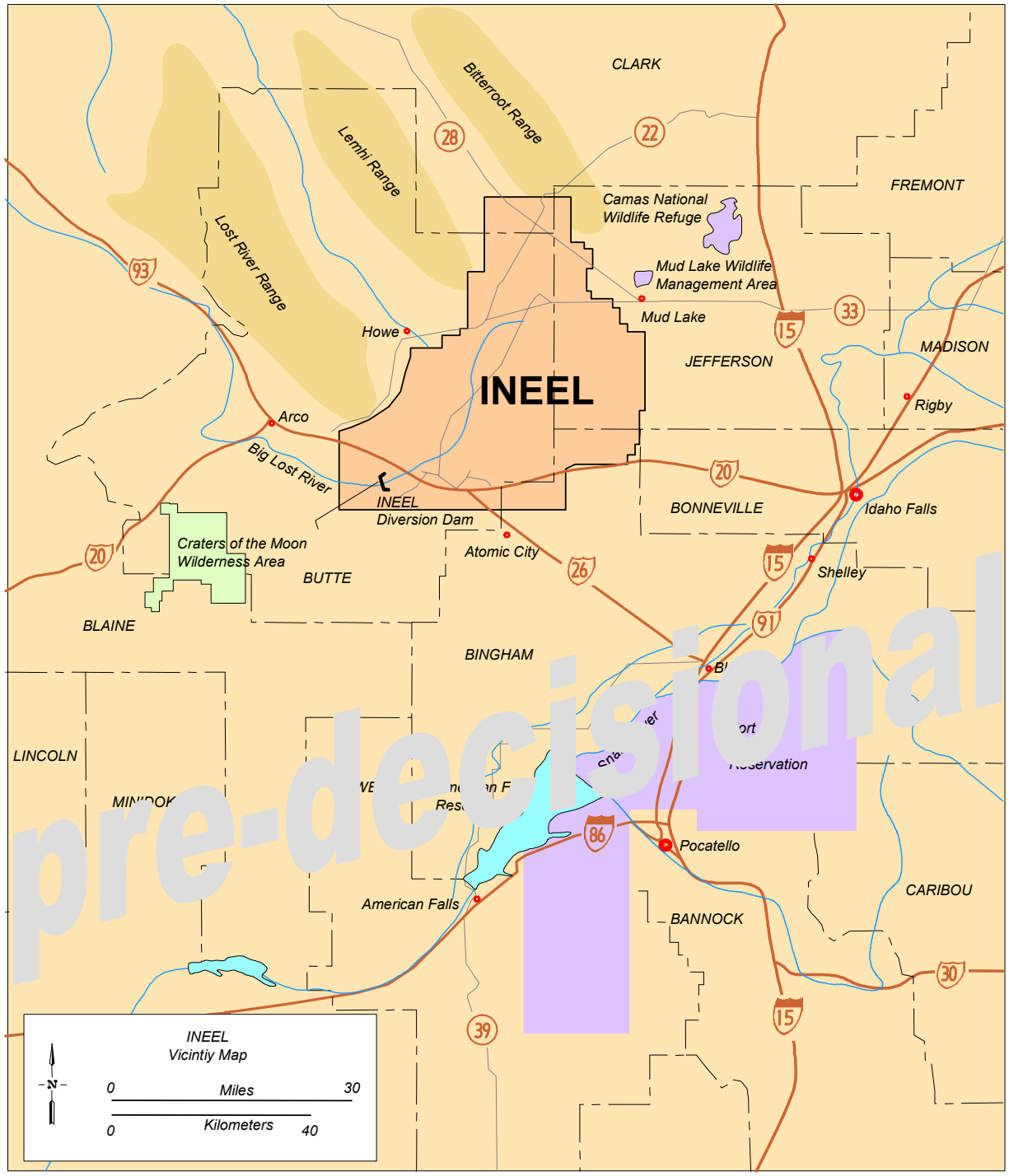

Figure 1-1. The INEEL and surrounding area.

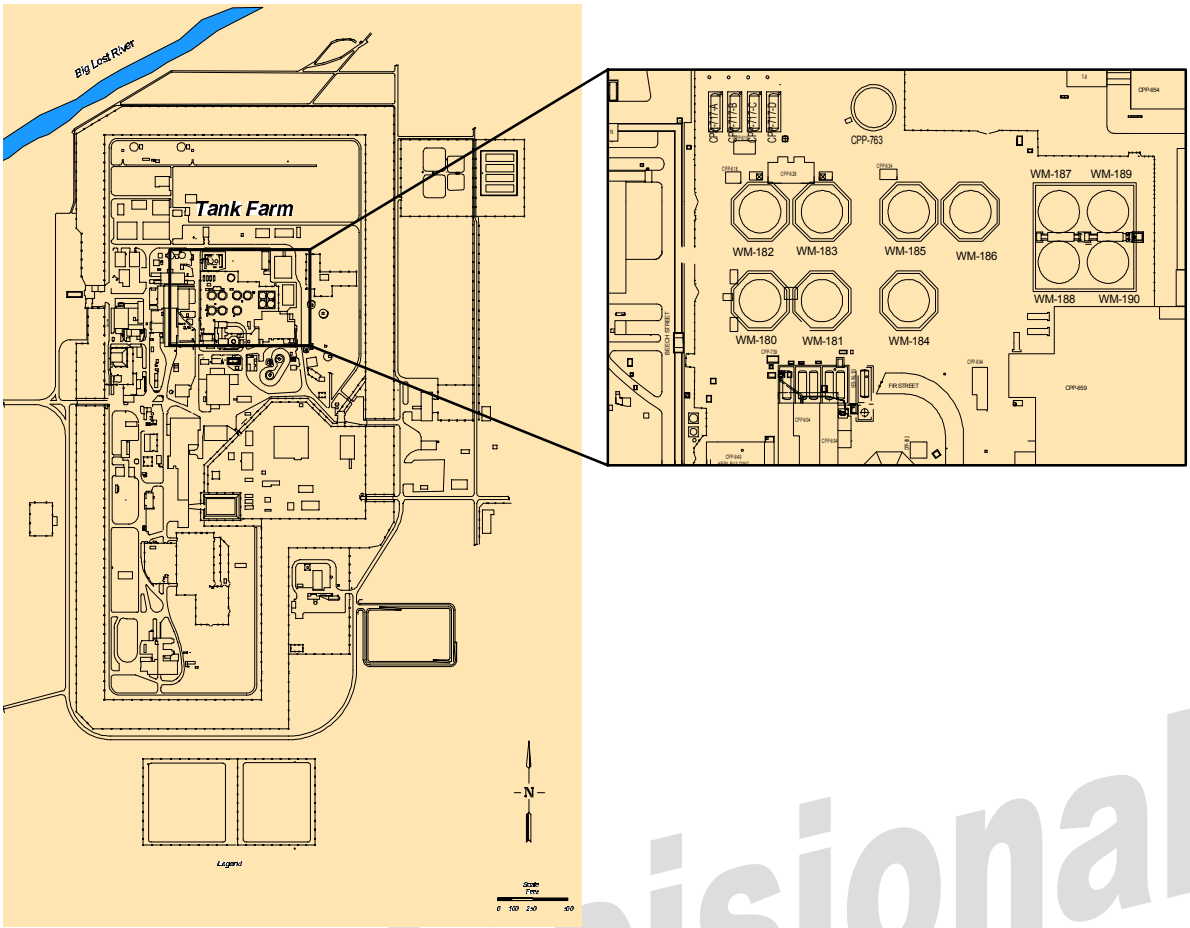

Figure 1-2. The INTEC facility and the location of the TFF.

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and subsequent court order with the State of Idaho,[e] all non-sodium-bearing HLLW was converted to calcine (a dry, stable, granular powder) by February 1998. The calcined HLLW is currently stored in calcine solid storage facilities at INTEC (62 *Federal Register* [FR] 182, 1997).

High-level waste (HLW)[f] (liquid and solid) and SBW are mixed wastes[g] dually regulated by the State of Idaho for hazardous constituents and by DOE for radioactive constituents. Because the TFF stores mixed wastes, TFF closure must

e. In October 1995, the State of Idaho, the Department of the Navy, and DOE settled the cases of *Public Service Co. of Colorado* v. *Batt,* No. CV 91-0035-S-EJL (D.Id.) and *United States* v. *Batt* No. CV-91-0065-S-EJL (D.Id.). The resultant Settlement Agreement and associated court order obligated DOE, among other things, to complete calcining non-sodium-bearing HLLW by June 30, 1998 (State of Idaho, DOE, and Department of the Navy 1995).

f. HLW is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel. It includes (a) liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and (b) other highly radioactive material that is determined, consistent with existing law, to require permanent isolation (DOE 1999a).

g. A mixture of hazardous wastes regulated under Subtitle C of the Resource Conservation and Recovery Act of 1976 (42 *United States Code* [USC] 6901 et seq., 1976) and radioactive wastes regulated under the Atomic Energy Act of 1954 (42 USC 2011–2259, 1992).

comply with closure requirements for hazardous waste as well as radioactive waste. For hazardous waste, closure must comply with the Hazardous Waste Management Act (HWMA) (State of Idaho 1983) and the Resource Conservation and Recovery Act (RCRA) as implemented by IDAPA 58.01.05.009 (2002) and 40 CFR 265 (2002), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." For radioactive waste, closure must comply with DOE Order 435.1, "Radioactive Waste Management," (DOE 2001a) and its associated manual (DOE 2001b) and guide (DOE 1999a).

Closure requirements for HLW facilities are specified in DOE Manual 435.1-1 (DOE 2001b). Three closure paths are allowed: decommissioning, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process (42 USC 960–9675, 1980), and closure according to an approved DOE closure plan. The TFF is proposed for closure under the latter, an approved DOE closure plan. Because the TFF will continue to operate until 2012, closure of the TFF will be performed in phases. Tanks WM-182 and WM-183 will be closed in the first phase. The closure of these two tanks will also serve as a proof-of-process demonstration of the waste removal, decontamination, and sampling techniques for the closure of the remaining 300,000-gal tanks.

1.1 Required Closure Documents

TFF closure activities have been designed to satisfy both DOE radioactive waste requirements and HWMA/RCRA hazardous waste requirements. Several closure documents are required to demonstrate compliance with each set of regulations. These documents are summarized in Table 1-1. For closure to meet DOE requirements, the primary documents needed are the DOE Tier 1 and Tier 2 Closure Plans, waste incidental to reprocessing (WIR) determination, performance assessment (PA), and composite analysis (CA) (DOE 2001b). To meet HWMA/RCRA closure requirements, the primary documents needed are the closure plan for clean closure (waste removal and decontamination) and a contingent closure and post-closure plan for closure as a hazardous waste landfill (IDAPA 58.01.05.009, 2002, and 40 CFR 265.197(c)(1), 2002). In addition, sampling and analysis plans (SAPs) will be developed for each phase of closure and will meet both DOE and HWMA/RCRA requirements. For the TFF closure, closure to HWMA/RCRA clean-closure standards is being proposed, rather than closure to landfill standards, because the waste removal and decontamination activities needed to remove the required radionuclides are anticipated to also address removal of the hazardous constituents to the HWMA/RCRA clean-closure standard. After closure of the entire TFF is complete, the planned end state is a deactivated HLW facility and a clean-closed HWMA/RCRA unit.

1.2 Tier 1 Closure Plan Requirements

DOE uses a two-tiered approach to closure plan development, review, and approval. The Tier 1 Closure Plan, to be approved by DOE Headquarters, may be based on preliminary information and is intended to define and bound the parameters of the closure action to ensure the long-term protection of the public and the environment from the closure of deactivated HLW facilities. The first tier includes

- Closure standards and performance objectives (for the radioactive constituents) (Sections 1.3, 4, and 5)
- Closure methodology (Section 2)
- Schedules (Section 2.6)
- Strategy for allocating closure standards and performance objectives to individual facilities and units to be closed at the site (Section 4)
- Waste characterization data (closure sampling) (Section 4.2)

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Table 1-1. Summary of required TFF closure documents.

Document Required	Description	Source
	DOE Deactivated HLW Facility Closure	
Tier 1 Closure Plan	Required by DOE for closure. Defines and bounds the parameters of closure actions. Defines approach that will be taken for ensuring the long-term protection of the public and the environment from deactivated HLW facility closure. To be approved by DOE Headquarters. Upon approval, an Authorization to Proceed is issued to the DOE Field Element Manager and closure activities may begin.	*Tier 1 Closure Plan for the Idaho Nuclear Engineering and Technology Center Tank Farm Facility at the INEEL*. Because the Tank Farm Facility (TFF) will continue to operate until 2012, the closure will be performed in phases.
Tier 2 Closure Plan	Required by DOE for closure. Provides detailed information related to a specific unit or facility closure action that is bounded by the analyses contained in the Tier 1 Closure Plan. To be approved by the DOE Field Element Manager.	To be finalized and approved after the Tier 1 Closure Plan is approved and an Authorization to Proceed is received.
Waste-Incidental-to-Reprocessing (WIR) Determination (See Section 1.3 for further information about the WIR determination.)	Required for DOE closure of a deactivated HLW facility. Demonstrates that residual radioactive waste present in facilities to be closed satisfies DOE Order 435.1 (DOE 2001a) WIR requirements. WIR demonstration shows that waste may be managed as low-level or transuranic waste. WIR criteria include requirements that (a) the waste must have been or will be processed to remove key radionuclides and (b) the waste must be managed pursuant to DOE's authority under the Atomic Energy Act of 1954, as amended (42 USC 2011–2259, 1992), and in accordance with DOE Order 435.1 and its associated manual and guide. For low-level waste designation, the waste must be managed to meet applicable safety requirements, and the waste must be incorporated in a solid physical form that does not exceed the applicable concentration limits for Class C as specified in 10 CFR 61.55 (2003).	For the TFF, a WIR determination has been developed[a] to demonstrate that the residual radioactive waste may be managed as low-level waste and the TFF may be closed as a deactivated HLW facility. This determination is now undergoing Nuclear Regulatory Commission review.

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Table 1-1. (continued).

Document Required	Description	Source
	DOE Deactivated HLW Facility Closure (continued)	
Performance Assessment (See Section 4 for a summary of the Performance Assessment.)	Required by DOE for closure. A systematic analysis to demonstrate that the closure will meet performance objectives. The point of compliance is the point of highest projected dose or concentration beyond a 300-ft (100-m) zone surrounding the waste.	*Performance Assessment for the Tank Farm Facility at the Idaho Nuclear Engineering and Environmental Laboratory* (DOE-ID 2003a). Results indicate that all performance objectives will be met.
Composite Analysis (See Section 5 for a summary of the Composite Analysis.)	Required by DOE for closure. Estimates the cumulative dose to a hypothetical member of the public from the deactivated HLW facility (here the TFF with its residual low-level radioactive waste) and other sources of radioactive material that may be left at the DOE site and that could interact with the deactivated HLW facility. The dose should not exceed the DOE primary dose limit of 100 mrem/yr and the composite analysis dose constraint of 30 mrem/yr within a 1,000-yr period.	*Composite Analysis for Tank Farm Closure* (DOE-ID 2003b). Results indicate that all performance measures will be met.
	HWMA/RCRA Hazardous Waste Closure	
Closure Plan to meet remove and decontaminate (clean-closure standard) (See Section 3 for more information on the HWMA/RCRA Closure Plan.)	Required by IDAPA 58.01.05.009 (2002) and 40 CFR Part 265.197(a) (2002). Describes closure activities necessary to achieve clean closure (the removal or decontamination of all hazardous wastes from the tank system). Clean closure to be demonstrated by showing that tank residuals meet site-specific action levels for hazardous constituents. HWMA/RCRA tank system closure also requires investigation and removal or decontamination of associated contaminated soils. However, the contaminated soils investigation and remediation associated with the TFF closure will be performed in accordance with Comprehensive Environmental Response, Compensation, and Liability Act requirements as described by the Federal Facility Agreement and Consent Order (IDHW, EPA, and DOE-ID 1991).	*Idaho Hazardous Waste Management Act/Resource Conservation and Recovery Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183* (DOE-ID 2001a).
Contingent Landfill Closure and Post-Closure Plan	Required by IDAPA 58.01.05.009 (2002) and 40 CFR 265.197(c)(1) (closure and post-closure care for tank systems) (2002). For tank systems that do not have adequate secondary containment, a contingent closure	*Contingent Landfill Closure and Post-Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183* (DOE-ID 2001b).

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Table 1-1. (continued).

Document Required	Description	Source
	and post-closure plan for closing the tank system as a hazardous waste landfill is required in addition to the closure plan for clean closure. The tank system will need to be closed as a landfill if clean-closure standards cannot be met.	Because the TFF will be closed in phases, a decision on whether or not to close the TFF as a landfill will not be made until all phases are complete. At that time, the concentration of hazardous constituents will be compared to action levels for the entire TFF.
DOE Deactivated HLW Facility Closure and HWMA/RCRA Hazardous Waste Closure		
Sampling and Analysis Plan for Piping	Describes sampling, analysis, and quality assurance and control procedures to be used for characterization of the piping.	*Sampling and Analysis Plan for the Post-Decontamination Characterization of the Process Waste Lines from INTEC Tank Farm Facility Tanks WM-182 and WM-183* (Portage Environmental 2001).
Sampling and Analysis Plan for Post-Decontamination (See Section 6 for more information on the sampling and analysis plans.)	Describes the sampling, analysis, and quality assurance and control procedures to be used for the characterization of the post-decontamination residuals remaining in the TFF. Results to be used to demonstrate that both hazardous and radioactive waste closure performance standards have been met.	*Sampling and Analysis Plan for the Post-Decontamination Characterization of the WM-182 and WM-183 Tank Residuals* (Portage Environmental 2002).

a. DOE-ID, 2002a, *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Residuals Waste-Incidental-to-Reprocessing Report,* DOE/ID-10777, Draft B, December.

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- Preliminary assessment of the projected composite performance of all units to be closed at the site (Section 5)
- Closure control plans (Section 8)
- Alternatives (if any) (Section 10)
- Stakeholder concerns and issues (Section 10.3).

After DOE-HQ reviews and approves the Tier 1 Closure Plan and issues an Authorization to Proceed, the second tier of the closure plan will be finalized. The Tier 2 Closure Plan provides the detailed closure information bounded by the Tier 1 Closure Plan. DOE-HQ approval is not required for the Tier 2 Closure Plan; rather, DOE Field Office approval is required, provided the conditions defined in the plan are not exceeded. A Tier 2 Closure Plan also is planned to be developed for each of the five phases of closure.

In addition to the guidance provided by DOE Manual 435.1-1, DOE has also developed the *DOE Deactivated High-Level Waste Facility Closure Federal Review Group Manual and Tier 1 Closure Plan Content Guide* (DOE 2000a). This manual was designed to assist Tier 1 Closure Plan preparation and guide DOE-HQ review of Tier 1 Closure Plans. Appendix A lists the review criteria for the Tier 1 Closure Plan, the PA, and the CA along with the appropriate section(s) of these documents where each criterion is addressed.

The Deputy Assistant Secretary for Waste Management must, after review and approval of this plan, issue an Authorization to Proceed to the appropriate Field Element Manager before closure activities may commence. The Authorization to

Proceed for closure activities represents approval from DOE-HQ of the Tier 1 Closure Plan, and other closure documents, as adequately representing and assessing the planned closure action. This approval includes the acceptance of the Tier 1 Closure Plan, supporting documentation (the PA, the CA, and the identification of long-term hazards), and establishment of the necessary closure activities to ensure protection of the public and the environment. Once the Authorization to Proceed is given, additional DOE Environmental Management (EM) Program approvals are not required, providing the boundaries and conditions in the Tier 1 Closure Plan are not exceeded.

1.3 Waste-Incidental-to-Reprocessing Determination

The WIR determination process provides the technical basis for the radiological classification of the residual wastes left at the TFF after closure. This requirement is taken from DOE Manual 435.1-1, Section II, B (DOE 2001b), which states,

> *Waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not high-level waste, and shall be managed under DOE's regulatory authority in accordance with the requirements for transuranic waste or low-level waste, as appropriate.*

DOE Manual 435.1-1, Section II, U (DOE 2001b), requires residual radioactive waste, in deactivated HLW facilities that will be closed in accordance with an approved closure plan, to meet WIR requirements. The WIR determination process allows certain waste streams produced during the generation of HLW to be managed as low-level waste[h] (LLW) or transuranic (TRU)[i] waste (DOE 2001b). This process ensures waste is classified properly and that DOE manages and disposes of these waste streams within its regulatory authority. DOE's policy is to dispose of HLW with commercial and defense SNF to a federal geologic repository. The WIR determination, as LLW or TRU waste, would eliminate the need for the residual waste to be disposed of to a HLW federal geologic repository. For the TFF, a WIR determination has been developed to evaluate the TFF residual radioactive waste as LLW (DOE-ID 2002a). The DOE Field Element Manager must approve the WIR determination.

DOE Manual 435.1-1, Section II, B, specifies two processes by which DOE may determine if reprocessed wastes may be managed as WIR: citation and evaluation (DOE 2001b). The citation process may be applied to SNF reprocessing waste that meets the description included in the "Statement of Proposed Policy" of Appendix D in 10 CFR 50 (2003), as not being HLW. Examples of such waste include contaminated job wastes, sample media, decontamination media and decontamination solutions, and laboratory clothing, tools, and equipment. This citation process cannot be used for the residual radioactive waste resulting from closure. Rather, the TFF residual radioactive tank waste is a candidate for the evaluation process because its removal is considered technically and economically impractical (DOE 2001b).

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h. *Radioactive waste that is not HLW, SNF, transuranic waste, byproduct material (as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended [42 USC 2011–2259, 1992]) or naturally occurring radioactive material* (DOE 2001b).

i. *Radioactive waste containing more than 100 nCi of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 yr, except for (a) high-level radioactive waste; (b) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the 40 CFR 191 disposal regulations; or (c) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61* (DOE 2001b).

The residual radioactive waste at the TFF can be managed as LLW if it meets the following criteria:

> *Has been processed, or will be processed, to remove key radionuclides to the maximum extent technically and economically practical; and*
>
> *Will be managed to meet safety requirements comparable to the performance objectives specified in 10 CFR Part 61, Subpart C, Performance Objectives; and*
>
> *Will be managed, pursuant to DOE's authority under the Atomic Energy Act of 1954, as amended, and in accordance with the provisions of Chapter IV of DOE Manual 435.1-1, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentrations limits for Class C LLW as specified in 10 CFR 61.55, Waste Classification, or will meet alternative requirements for waste classification and characterization as DOE may authorize* (DOE 2001b).

The WIR determination demonstrates that the cleaning and decontamination activities for the TFF are sufficient for the contaminated components (tanks, piping, and ancillary equipment) to meet Class C LLW limits. In addition, it was determined that key radionuclides have been removed from the waste and that the performance objectives are satisfied by the planned TFF closure. The WIR has been submitted to the Nuclear Regulatory Commission (NRC) for review and will be approved by DOE prior to tank grouting.

1.4 Performance Assessment

The PA (DOE-ID 2003a) supports the Tier 1 Closure Plan through evaluation of the radiological waste constituents at the TFF. The methodology used for preparing the PA is based on information and guidance found in

- *Guidelines for Radiological Assessment of DOE Low-Level Radiological Waste Disposal Sites* (Case and Otis 1991)
- Guidance from DOE Order 435.1 (2001a), Manual 435.1-1 (2001b), and Guide 435.1-1 (DOE 1999a)
- *Department of Energy Deactivated High-Level Waste Facility Closure Federal Review Group Manual and Tier 1 Closure Plan Content Guide* (DOE 2000a)
- *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses* (DOE 1999b).

The PA was initiated by identifying the scope of the project and the applicable performance objectives. Next, site characterization data, features of the environment, and facility design features were documented. The bounding radiological source inventory for the TFF was determined based on analytical data and process knowledge. The conceptual model was developed, the pathways and exposure scenarios were selected, and a dose-model was associated with each scenario. Then, the results of modeling were compared to the performance objectives. The PA follows methods appropriate for the residual waste stream, which is projected to be LLW. This assessment is consistent with the requirements of a PA as defined in Chapter IV, Section P.(2), of DOE Manual 435.1-1 (DOE 2001b). Section 4 discusses the performance objectives for the PA and summarizes the PA results, which demonstrates compliance with the performance objectives.

1.5 Composite Analysis

In accordance with DOE Manual 435.1-1 facility and site closure plan requirements (DOE 2001b), a CA of the TFF site was performed as part of the closure process. The *Composite Analysis for Tank Farm Closure* (DOE-ID 2003b) presents the results of a site-specific radiological assessment that accounts for all sources of radioactive material that may be left

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at other INEEL facilities and that may interact with any source remaining at the TFF. The CA provides an estimate of the projected dose to a hypothetical member of the public from the existing or future disposal facilities. This projected dose is compared with the DOE primary dose limit of 100 mrem/yr and with the 30 mrem/yr dose constraint within a 1,000-yr period (DOE 2001b).

The CA provides information useful for planning. For example, the results of the CA can assist in identifying the sources that most significantly contribute to the total projected dose and in deciding on priorities for remediation or closure alternatives for active or inactive closure sites. Hazard implications for some sources may be so negligible that little would need to be done beyond land control, minor maintenance, and monitoring (DOE 1999a). The CA uses methodologies and assumptions similar to, or derived from, the PA but with the addition of radioactive source terms from environmental remediation sites, other INTEC facilities, and other INEEL facilities. Section 5 discusses the performance objectives for the CA and summarizes the CA results, which demonstrate that all performance objectives will be met.

1.6 Major Assumptions

The closure approach discussed in this Tier 1 Closure Plan is based on several assumptions, which include

- The WIR determination will be approved to classify any remaining tank residuals as LLW.
- The actions outlined in the Tier 1 Closure Plan will be bound by any alternatives selected in the *Idaho HLW and Facilities Disposition Final Environmental Impact Statement* (EIS) (DOE 2002).
- Sufficient treatment, storage, and disposal facilities will be available for all liquid and solid waste removed from the tanks or generated during closure activities. WM-187 is planned to be used for storage of liquids. Solids and the HLLW evaporator will be used for evaporation of liquids. These facilities are not included in the scope of the closure.
- A key element of the PA and CA is the radiological source inventory, which is an estimate of the radionuclides and their calculated activities remaining after TFF closure. The source inventory is based on the highest measured concentration of the radionuclides found in the solutions or solids in WM-182, WM-183, and WM-188. Estimates of non-measured radionuclides are calculated from ORIGEN2 (Croff 1980) runs based on measured activity of ^{137}Cs in Tank WM-188. These estimates provide the bounding values. As such, the source inventory is a bounding inventory that should not be exceeded during the closure phases.

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2. CLOSURE SCOPE AND METHODOLOGY

This section presents descriptions of the TFF facility, its operational history, the major objectives of the closure design, and the closure boundary, methodology, and schedule. Appendix B provides a description of the INEEL site including geography (site geography, demography, use plans), meteorology, ecology, geology (seismology, volcanology, geologic resources, and natural background radiation), hydrology (surface water, groundwater, and water resources), and geochemistry that pertain to the performance of the TFF closure actions.

2.1 Closure Objectives

The TFF closure design was developed to meet three major objectives to comply with DOE and HWMA/RCRA requirements.

- Closure of the tanks will meet radionuclide removal requirements as specified in DOE Order 435.1 (DOE 2001a). This objective is the focus of this Tier 1 Closure Plan and is discussed in detail throughout the rest of the document. Appendix A lists the criteria that are used for review of Tier 1 Closure Plans and the sections in this plan where these criteria are addressed.

- Clean closure of the tanks will meet the requirements of Idaho HWMA/RCRA for hazardous constituents. HWMA/RCRA closure plans will be developed for each phase of closure. The strategy to meet the clean-closure objective is the removal or decontamination of all hazardous wastes from the TFF. The regulations do not require complete removal of all contamination (i.e., removal to background levels at or from a closing unit) for clean closure. Some limited quantity of hazardous constituents may remain in the tanks after clean closure, provided the concentrations of hazardous constituents are below site-specific action levels. These action levels are protective of human health and the environment. The determination regarding whether or not clean closure has been achieved at the TFF will be made during final closure when all tanks and components have been closed. In addition to the clean-closure plan previously referenced, a contingent landfill closure and post-closure plan has been prepared (DOE-ID 2001b) in accordance with IDAPA 58.01.05.009 (2002) and 40 CFR 265.197(c)(1) (2002).

- Closure of the tanks will ensure the drinking water is protected from contamination resulting from the closed TFF. The Safe Drinking Water Act (SDWA) requires that actions be taken to protect drinking water at its sources: rivers, lakes, reservoirs, springs, and groundwater. The requirements defined for closure under both DOE Order 435.1 and Idaho's HWMA/RCRA regulations will provide the activities to ensure the SDWA requirements are met.

The TFF (Figure 2-1), as part of the INEEL's INTEC facility, is located in the south-central portion of the INEEL. INTEC was established in 1953 as a fuel reprocessing facility for defense projects, research, and storage of SNF until 1992 when DOE ended the reprocessing mission. The current mission of INTEC is to receive and store SNF and radioactive wastes, treat and convert wastes, and develop new technologies for waste management.

2.2 Facility Description

The TFF consists of 15 stainless-steel storage tanks contained in concrete vaults, with underground piping and other associated structures. The TFF is part of the SNF reprocessing system at INTEC and stores liquid mixed waste from previous SNF reprocessing and operations and decontamination activities. The

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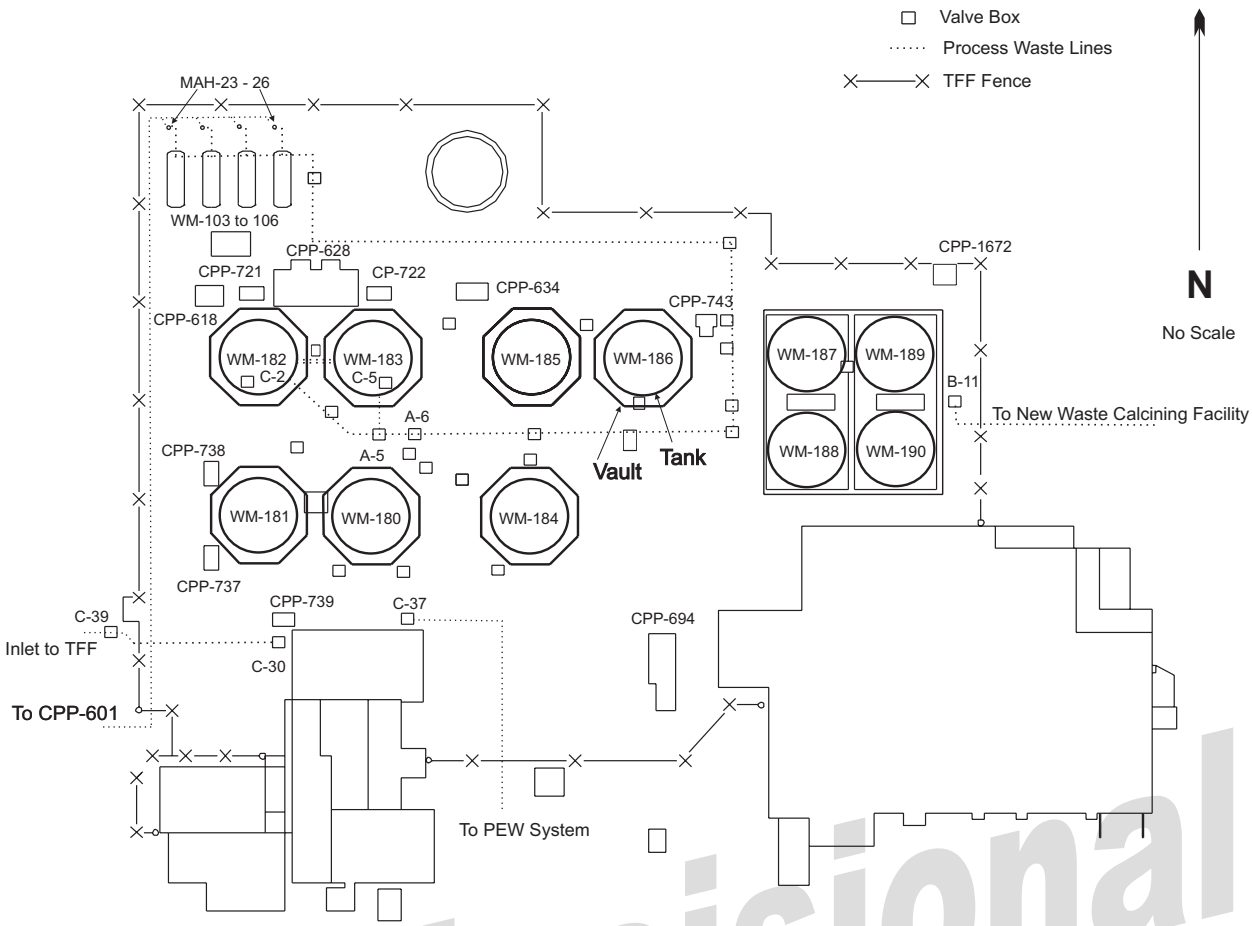

Figure 2-1. The TFF showing the layout of the tanks, buildings, and primary inlet lines.

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tanks, vaults, and associated equipment encompass the major portion of the TFF.

2.2.1 Tanks

The 15 tanks vary in size and design as shown in Tables 2-1 and 2-2. Nine of the tanks, WM-182 through WM-190, each have a capacity of 300,000 gal, are 50 ft in diameter, 21 ft high, and are contained in unlined, underground concrete vaults, as depicted in Figure 2-2 (INEEL 1999a). The two basic vault designs for this group of tanks are monolithic square and pillar and panel, which are discussed in detail in Section 2.2.2. The two tanks designated as WM-180 and WM-181 are both 318,000 gal in size, 50 ft in diameter, and 23 ft high, and are contained in monolithic octagonal vaults. The 300,000-gal tanks are active. All of the tanks have domed roofs from 8.5 to 8.7 ft high.

Tank risers provide access to the 300,000 and 318,000-gal tanks (INEEL 1999a). Each tank has four 12-in. diameter risers extending from the top of the tanks through the 10-ft (3-m) soil cover to aboveground concrete enclosures where the riser is capped. Most of the risers for both the tanks and vaults have equipment installed in them such as liquid-level probes, corrosion coupons, waste transfer piping, and steam jets. The jets are piped to control valves located in stainless-steel-lined concrete boxes near each tank. The steam jets are currently fixed at a height of 3 to 12 in. above the tank floors.

The four remaining tanks are stainless steel and each have a capacity of 30,750 gal (referred to as the 30,000-gal tanks), are approximately 11.5 ft in diameter, 38 ft long, and covered by compacted gravel. Unlike the larger tanks, the 30,000-gal tanks are not contained in vaults but rest on

Table 2-1. Design information summary for 300,000-gal tanks at the TFF.[a]

Tank Identification Number	WM-180	WM-181	WM-182	WM-183	WM-184	WM-185	WM-186	WM-187	WM-188	WM-189	WM-190
Design organization	Foster-Wheeler	Foster-Wheeler	Blaw-Knox	Blaw-Knox	Blaw-Knox	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.
Tank subcontractor	Chicago Bridge and Iron (CBI)	CBI	CBI	CBI	CBI	CBI	CBI	Hammond Iron	Hammond Iron	Industrial Contractors	Industrial Contractors
Year constructed	1951–1952	1951–1952	1954–1955	1954–1955	1954–1955	1957	1955–1957	1958–1959	1958–1959	1964	1964
Initial service date	1954	1953	1955	1958	1958	1959	1962	1959	1963	1966	Spare
Design codes	Unknown	Unknown	API-12C	API-12C	API-12C	API-12C	API-12C	API-12C	API-12C	API-650	API-650
Cooling coils	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Tank diameter (ft)	50	50	50	50	50	50	50	50	50	50	50
Tank height to springline (ft)	23	23	21	21	21	21	21	21	21	21	21
Tank capacity (gal)	318,000	318,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Lower tank thickness (in.)	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125
Upper tank thickness (in.)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Corrosion allowance (mils)	Unknown	Unknown	125	125	125	125	125	125	125	125	125
Type of stainless steel	347	347	304 L	304 L	304 L	304 L	304 L	304 L	304 L	304 L	304 L
Design specific gravity	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

Physical Characteristic	Dimension	
Dome height	8.7 ft (WM-180 and WM-181)[b]	8.5 ft (WM-182 through WM-190)[b]
Approximate total tank volume	2,000 yd^3 [b,c] (WM-180 and WM-181)	1,825 yd^3 [b,c] (WM-182 through WM-190)
Approximate dome volume	330 yd^3 [b,d] (WM-180 and WM-181)	300 yd^3 [b,d] (WM-182 through WM-190)

a. Data taken from the *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Conceptual DOE and HWMA/RCRA Closure Approach* (INEEL 2000a).
b. Values shown in table are approximations to aid in cost estimation and provide a general tank description.
c. Estimated volume is based on the physical tank volume and not the tank capacity.
d. Volume calculated using standard spherical cap equation, a diameter of 50 ft, and appropriate dome height.

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Table 2-2. Design information summary for 30,000-gal tanks at the TFF.[a]

Tank Identification Number	WM-103	WM-104	WM-105	WM-106
Design organization	Blaw-Knox Company	Blaw-Knox Company	Blaw-Knox Company	Blaw-Knox Company
Vendor	Alloy Fabricators	Alloy Fabricators	Alloy Fabricators	Alloy Fabricators
Year constructed	1954–1955	1954–1955	1954–1955	1954–1955
Total tank volume (gal)	30,750	30,750	30,750	30,750
Tank cylindrical length (ft)	38	38	38	38
Spherical heads (two per column) approximately 2-ft deep	ASME[b] standard flanged and dished heads	ASME standard flanged and dished heads	ASME standard flanged and dished heads	ASME standard flanged and dished heads
Total tank length (ft)	42	42	42	42
Tank inner diameter (ft)	11.5	11.5	11.5	11.5
Tank wall thickness (in.)	11/16	11/16	11/16	11/16
Tank supporting base slab size (ft)	47.5 × 17 × 1.25 thick	47.5 × 17 × 1.25 thick	47.5 × 17 × 1.25 thick	47.5 × 17 × 1.25 thick
Liquid containment perimeter curb size (in.)	12 high × 9 wide	12 high × 9 wide	12 high × 9 wide	12 high × 9 wide
Tank access risers	Three 6-in. diameter One 3-in. diameter	Three 6-in. diameter One 3-in. diameter	Three 6-in. diameter One 3-in. diameter	Three 6-in. diameter One 3-in. diameter
Sump riser (concrete pipe) diameter (in.)	24 Pipe wall is 3-in. thick	24 Pipe wall is 3-in. thick	24 Pipe wall is 3-in. thick	24 Pipe wall is 3-in. thick
Sump dimensions (ft)	2 × 2 × 2	2 × 2 × 2	2 × 2 × 2	2 × 2 × 2
Buried tank depths (measured to tank bottom) (ft)	28.5	28.5	28.5	28.5

a. Data taken from *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Conceptual DOE and HWMA/RCRA Closure Approach* (INEEL 2000a).
b. American Society of Mechanical Engineers.

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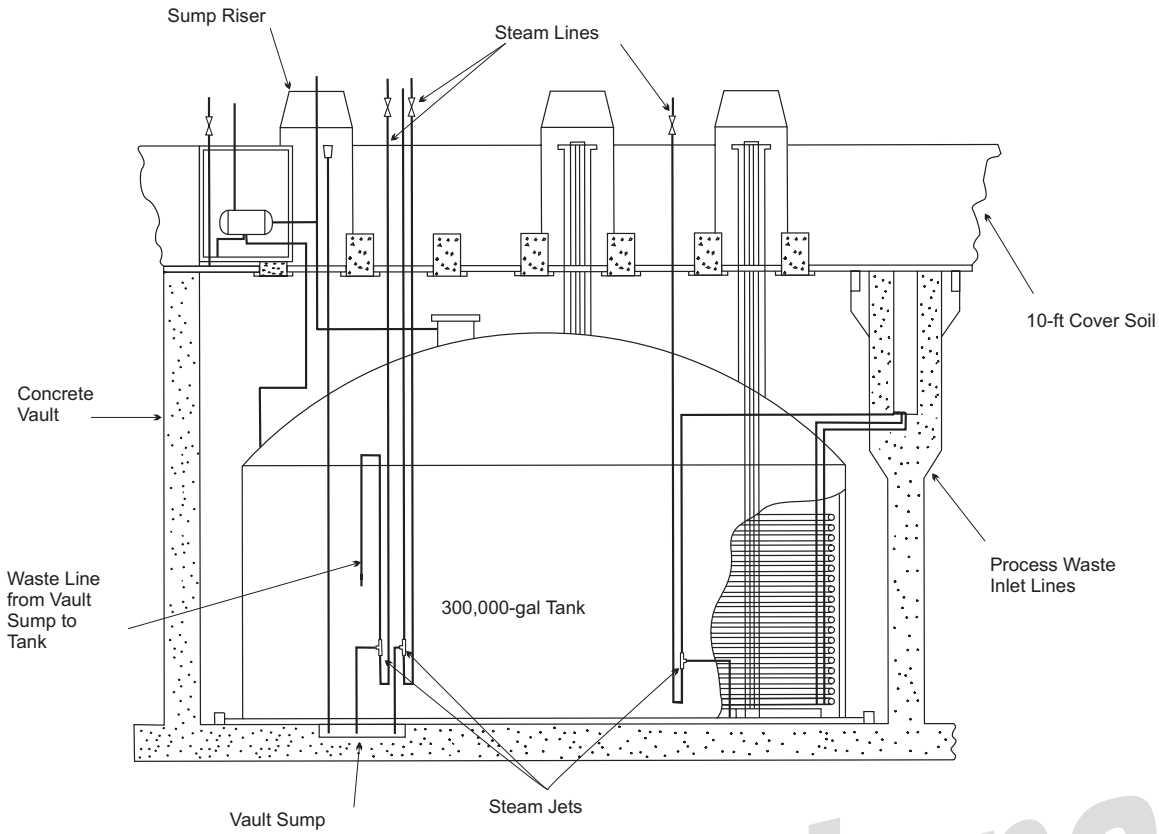

Figure 2-2. Cross-section view of vaults and tanks (drawing not to scale).

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reinforced concrete slabs that are 47.5 × 17 × 1.25 ft. All four tanks contain stainless-steel, closed-loop cooling coils to control the temperature of liquid wastes. Four or five risers in each tank extend to ground level to provide access. Each tank is equipped with a steam jet, and the control valves for the jets are located in a valve box adjacent to the tanks (INEEL 1999a).

2.2.2 Vaults

The vaults are made of concrete but vary in size and design as described in Table 2-3. The three basic designs are monolithic octagonal, pillar and panel octagonal, and monolithic square Figure 2-3) (INEEL 1999a). The vault floors are located approximately 45 ft (14 m) belowground and set on bedrock. The vault roofs are reinforced concrete and are covered with approximately 10 ft (3 m) of soil to provide radiation shielding.

The monolithic octagonal vaults (Figure 2–3) were constructed from 1950 to 1952. Tanks WM-180 and WM-181 are each contained in a monolithic vault (INEEL 1999a). The vault walls were cast in place during construction. The vault bases also were poured in place and rest on bedrock. Each floor is cast flat with one sump area that is 2 ft^2 and 4 ft deep to allow liquids to drain. The sump is emptied using a steam jet accessed through a vault or sump riser. The tanks are bolted directly to the flat octagonal floor.

The pillar and panel octagonal vaults (Figure 2-3) were constructed from 1954 to 1957. Tanks WM-182 through WM-186 are each contained in a pillar-and-panel vault (INEEL 1999a). The octagonal floors were cast in place on bedrock. Each floor is conically shaped, with the highest point at the center tapering down 4 in. (10 cm) near the slab edge, creating a drainage path for any liquids to the outside edge of the floor. Two sumps located on the north and south sides of the vault floor are cast in place and are equipped with steam jets to remove any liquids

Table 2-3. Design information summary for the TFF vaults.[a]

Vault Identification Number	CPP-780	CPP-781	CPP-782	CPP-783	CPP-784	CPP-785	CPP-786	CPP-713			
Tank Identification Number	WM-180	WM-181	WM-182	WM-183	WM-184	WM-185	WM-186	WM-187	WM-188	WM-189	WM-190
Design organization	Foster-Wheeler	Foster-Wheeler	Blaw-Knox	Blaw-Knox	Blaw-Knox	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.	Fluor Corp.
Year constructed	1951–1952	1951–1952	1954–1955	1954–1955	1954–1955	1957	1955–1957	1958–1959	1958–1959	1964	1964
Vault type	Monolithic octagonal [b]	Monolithic octagonal [b]	Pillar and panel octagonal	Pillar and panel octagonal	Pillar and panel octagonal	Pillar and panel octagonal	Pillar and panel octagonal	Monolithic square [b]	Monolithic square [b]	Monolithic square [b]	Monolithic square [b]
Inside width (ft)	56	56	58.9	58.9	58.9	58.8	58.8	56	56	56	56
Wall thickness (ft)	2.33 or 1.75	2.33 or 1.75	0.5	0.5	0.5	0.542	0.542	N = 3.5	N = 3.5	N = 3.5	N = 3.5
								S = 3.5	S = 3.5	S = 3.5	S = 3.5
								W = 1.5	W = 1.5	W = 3.5	W = 3.5
								E = 3.5	E = 3.5	E = 1.5	E = 1.5
Inside vault wall height (ft)	27.33	27.33	32	32	32	29.5	29.5	32.6	32.6	32.6	32.6
Number of vault risers and sumps	1	1	2	2	2	2	2	2	2	2	2
Maximum roof thickness (ft)	5.75	5.75	3.66	3.66	3.66	3.5	3.5	4.5	4.5	4.0	4.0
Minimum roof thickness (ft)	1.25	1.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vault top to grade (ft)	6.75	6.75	8.5 to 9	9 to 9.5	9	9	9	9	9	9	9
Total vault volume (yd^3)	3,386	3,386	3,229	3,229	3,229	3,229	3,229	3,737	3,737	3,737	3,737
Vault volume with tank in vault (yd^3)	1,384	1,384	1,404	1,404	1,404	1,404	1,404	1,911	1,911	1,911	1,911

a. Data taken from *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Conceptual DOE and HWMA/RCRA Closure Approach* (INEEL 2000a).
b. Cast in place.

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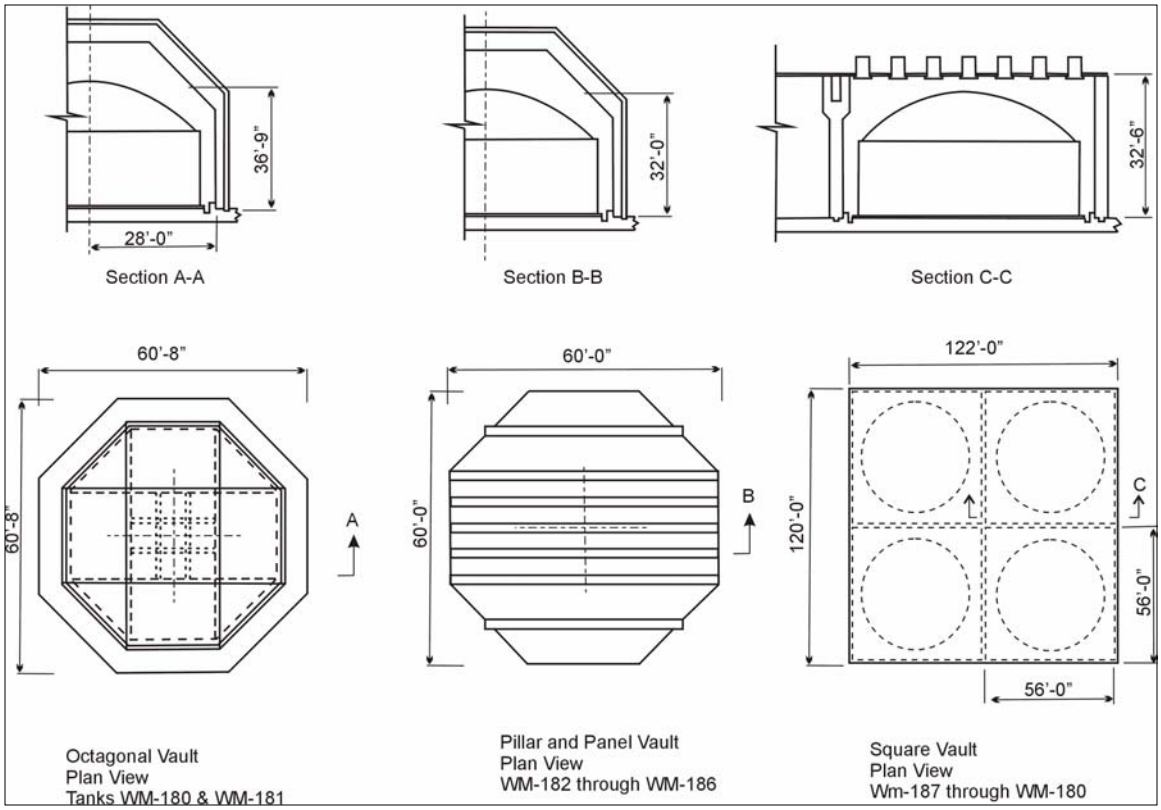

Figure 2-3. Plan and section views of the INTEC TFF vaults and tanks.

present. A 6 × 6-in. curb cast into the floor surrounds a sand pad. The tanks in these vaults are set directly on the sand pad. The vault walls are constructed of pillars and panels and the panels are pre-cast and set in place between the vaults.

The monolithic square vaults (Figure 2-3) were constructed from 1958 through 1964. Tanks WM-187 through WM-190 are each contained in a monolithic square vault (INEEL 1999a). These vaults were cast in place with the floors placed directly onto the bedrock. Each of the tank floors is tapered from the highest point in the center of the tank to the tank perimeter, 4 in. (10 cm) lower; thus creating a drainage path. Two sumps are cast into the floor of each vault and are equipped with steam jets. A 6 × 6-in. curb cast into the floor surrounds a sand pad upon which the tanks are set.

2.2.3 Piping and Valve Access

The TFF also includes an extensive system of waste transfer piping, decontamination piping, and instrumentation lines. The belowground waste transfer piping is encased in either stainless-steel-lined concrete trenches or piping, and both provide secondary containment. The trenches are designed with drainage and piping that allows for the stainless-steel surfaces to be decontaminated and the decontamination fluids to be drained to the vaults. As previously discussed, any liquids entering the vaults will drain to the sumps and can be removed with a steam jet. Liquid waste can be transferred to and from the various tanks in the system through the process waste piping.

The valve boxes are underground stainless-steel-lined structures that allow access to valves and piping for inspections and repairs. Transfer and routing of liquid waste involves manually operating the valves in the valve boxes. Piping from the valve boxes to the vault sumps allows for decontamination of the interior of the boxes, which have been decontaminated periodically over the life of the TFF.

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2.2.4 Ventilation System

A centralized vessel off-gas (VOG) system is designed to maintain negative pressure and balance airflow in each of the 300,000-gal tanks (INEEL 1999a). The VOG piping consists of 10-in. diameter underground piping from the tanks to condenser pits and then to blowers located in CPP-605, which discharge air to the INTEC main exhaust stack. During closure, the VOG system for the tanks being closed may be isolated. A temporary system may be needed to ensure proper tank ventilation. Isolating these tanks from the main system will require modifying the operation, or the equipment, of the remaining VOG system to allow for continued operation.

2.2.5 Cooling System

Eight of the tanks, designed to hold HLW and SBW, have cooling systems to maintain a temperature that minimizes corrosion of the tanks. The tanks with cooling coils are WM-180, WM-182, WM-183, WM-185, WM-187, WM-188, WM-189, and WM-190. The cooling coil network of piping is situated horizontally and vertically on the inside wall perimeter and floor of both of the tanks. The coils exit near the top of the tanks where they connect to piping that runs to the cooling system in CPP-628. Instrumentation lines from the tanks also terminate in CPP-628 and support various tank-monitoring activities (temperature, pressure, liquid level, etc).

2.3 INTEC Operations and Wastes Generated

Reprocessing operations at INTEC took place from 1952 to 1991. These operations involved a three-cycle solvent extraction process to recover enriched uranium from SNF. The fuel dissolution process varied slightly depending on the type of fuel to be reprocessed. In overview, SNF was dissolved in hydrofluoric or nitric acid to form a uranyl nitrate solution that was suitable for solvent extraction. The solution remaining after the first extraction cycle was considered HLW and was stored in the TFF. The liquid remaining from the second and third extraction cycles, and solutions resulting from decontamination activities, were first concentrated by evaporation and then stored separately in the TFF. This waste is generally referred to as SBW because it is high in sodium content from decontamination activities. Although reprocessing operations have ceased, the TFF continues to receive waste from INTEC plant operations and decontamination activities. This waste is referred to as newly-generated liquid waste (DOE 1999a).

2.3.1 Fuel Dissolution

Five types of fuel dissolution processes were used during reprocessing. In the aluminum dissolution process, aluminum-based fuels were dissolved in a nitric acid solution in the presence of a mercuric nitrate catalyst. Zirconium-based fuels were dissolved using the fluorinel dissolution process. This process used hydrofluoric and nitric acids, aluminum nitrate, and the soluble nuclear poisons of cadmium and boron. In the electrolytic dissolution process, stainless-steel fuels were dissolved in nitric acid while a direct electrical current was passed through the fuel. The Space Nuclear Propulsion Program (ROVER) dissolution process was used to dissolve graphite fuels. ROVER fuels consisted of either an uncoated or pyrolytic-carbon-coated graphite matrix that contained uranium dispersed throughout the matrix as uranium dicarbide fuel particles. These fuels were first burned in oxygen to remove the graphite. The uranium materials were then dissolved in hydrofluoric and nitric acids. Custom processing in specially designed pilot-plant equipment with material-specific dissolvents was used for nuclear material that was incompatible with established dissolution processes. For example, fuels with nontraditional cladding materials, impurities, excessively high radiation levels, or small amounts of recoverable fissile material required custom fuel processing methods (Westinghouse Idaho Nuclear Company [WINCO] 1986).

2.3.2 Fuel Extraction

In the first cycle of fuel extraction, uranium was extracted from the uranyl nitrate solution into a solution of tributyl phosphate in dodecane. The aqueous raffinate stream from this extraction,

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which included the fission products, was sent to the TFF unless the uranium concentration remained high enough for further extraction (WINCO 1986).

The second- and third-cycle extraction processes used hexone extraction to purify the uranium product from the first-cycle extraction. The process used the solvent methyl isobutyl ketone (hexone) to separate the uranium from residual fission products and TRU elements such as neptunium and plutonium. The waste material containing TRU and fission products was evaporated to reduce its volume and then sent to the Waste Calcining Facility (WCF) and later to the New Waste Calcining Facility (NWCF) for calcination (INEEL 2000b).

2.3.3 Waste Types and Composition

The types of radioactive liquid waste generated at INTEC can be separated into the eight basic categories listed below. Table 2-4 summarizes the typical chemical compositions of the most abundant waste types.

- Aluminum waste from the dissolution of aluminum fuels in nitric acid
- Zirconium fluoride waste from the dissolution of zirconium fuels in hydrofluoric acid
- Coprocessing waste that results when dissolver product from aluminum fuel dissolution is used as the complexing agent for zirconium dissolver product before introduction to the extraction system
- Fluorinel waste from the dissolution of zirconium fuels in hydrofluoric acid and nitric acid
- Stainless-steel waste from the electrolytic dissolution of stainless-steel fuels in nitric acid
- ROVER waste from the dissolution of graphite-type fuels in hydrofluoric acid and nitric acid
- Custom processing waste that is the second- and third-cycle raffinates resulting from processing custom fuels
- SBW that results from HLLW evaporator bottoms and sodium-bearing decontamination solutions.

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Table 2-4. Typical chemical composition of the most common waste types generated at the INTEC.

Waste Type[a]	Aluminum (M)	Zirconium (M)	Fluorinel (M)	Stainless Steel (M)	Sodium Bearing (M)
Acid (H+)	1	1.5	1.9	2.5	1.2
Aluminum	1.3	0.6	0.3	0.65	0.6
Boron	0.01	0.15	0.2	0	0.01
Cadmium	0	0	0.13	0	0.0
Calcium	0.06	0.02	0.02	0.005	0.04
Chromium	0	0	0	0.01	0.003
Fluoride	0	2.5	2.7	0	0.05
Iron	0.01	0.01	0.01	0.06	0.02
Nitrate	4.6	2.6	2.3	3	4.6
Potassium	0.003	0.007	0.001	0	0.2
Sodium	0.04	0.04	0.03	0.01	1.6
Sulfate	0.01	0	0.08	0.06	0.06
Zirconium	0	0.4	0.4	0.01	0.0

a. INEEL 1999a.

All first-cycle raffinates were found to be acidic, with a hydrogen-ion concentration between 1 and 3 M. Radionuclides in the first-cycle raffinates exhibited a typical radioactivity level from 5 to 40 Ci/gal. The raffinates from zirconium dissolution, coprocessed zirconium, and aluminum dissolution were fluoride-bearing wastes. The first-cycle raffinates from the dissolution of aluminum and stainless-steel fuel were non-fluoride bearing (INEEL 2000b).

The chemical and radiochemical composition of the wastes and the amount of heat generated varied with the type of fuel being processed, decay time before processing, and fuel burn-up rate. Chemicals in concentrations up to 4 M and large quantities of fission products were present. The most abundant chemicals present were aluminum and nitrate in the non-fluoride waste and aluminum, zirconium, fluoride, and nitrate in the fluoride waste (INEEL 2000b).

The composition of second- and third-cycle raffinates was essentially the same for all fuel types processed. The fission product activity in these wastes was low enough that little heat was generated, which made cooling unnecessary. The principal nuclides present were ^{137}Cs, ^{90}Sr, and ^{238}Pu. The predominant chemicals in the second- and third-cycle combined waste were aluminum and nitrate. The waste was found to be acidic, with hydrogen ion concentration between 0.1 and 1.6 M (INEEL 2000b).

In February 1998, calcination of all HLLW at the TFF was complete. The production of SBW was dependent on the quantity and type of work performed at INTEC and was generated primarily from decontamination and decommissioning activities (D&D) and from the off-gas produced during the calcination process. However, the TFF will continue to be used as a storage facility for SBW and newly-generated waste until 2012, when the wastes will be treated for disposal. Despite the age of the tanks, corrosion monitoring has shown that they could continue to provide reliable service for an additional 20 to 40 yr (INEEL 2000b).

2.3.4 Waste Volumes

Each of the 300,000-gal tanks was administratively limited to holding a maximum of 285,000 gal. Figures 2-4 through 2-14 show the volumes and types of waste stored in the tanks from January 1953 to January 1999 (INEEL 1999b).

The volumes of SBW in the TFF tanks as of December 31, 2002, are summarized in Table 2-5. These wastes originate from previous reprocessing and decontamination activities, and also include newly-generated liquid waste. Tank WM-190 contains a relatively low volume of slightly-contaminated water (500 gal [2,000 L]), because the tank was designated as an emergency spare tank and was never put into service. The waste in Tank WM-190 is the result of valve leakage and is mixed with water from precipitation.

2.4 Closure Boundary

The closure boundary for the TFF is located at valve boxes inside the fence where process waste lines feeding or leaving the facility can be isolated (Figure 2-15). Lines outside of the isolation points will be left accessible for subsequent closure projects but are not included in the TFF closure (INEEL 2000b). The primary isolation points are the process waste lines to and from the

- NWCF at Valve Box B-11
- Line to the HLLW evaporator system at Valve Box C-37
- Primary inlet line to the TFF at Valve Box C-30
- Abandoned connections from Tanks WM-103 through WM-106 to CPP-601.

As TFF closure progresses, tanks to be closed will be isolated from the rest of the TFF and the wastes transferred to the remaining tanks. Therefore, the volume of waste in the tanks will change as closure progresses. The TFF closure does not include the contaminated soils

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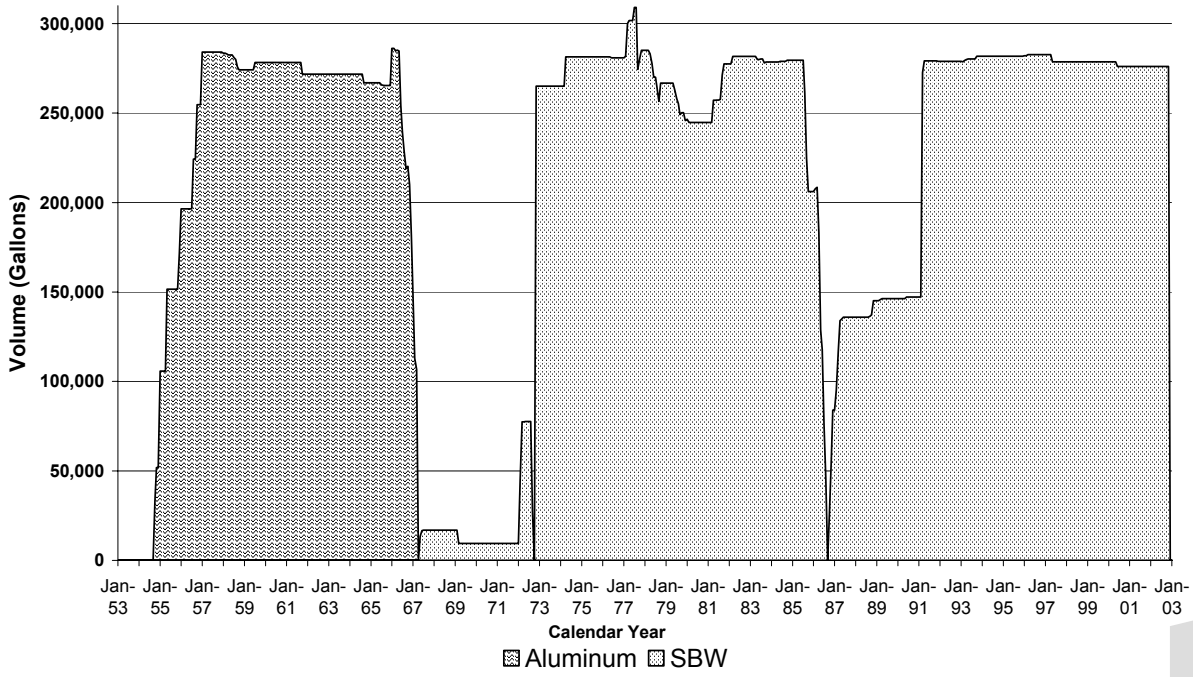

Figure 2-4. Historical volumes of waste stored in Tank WM-180.

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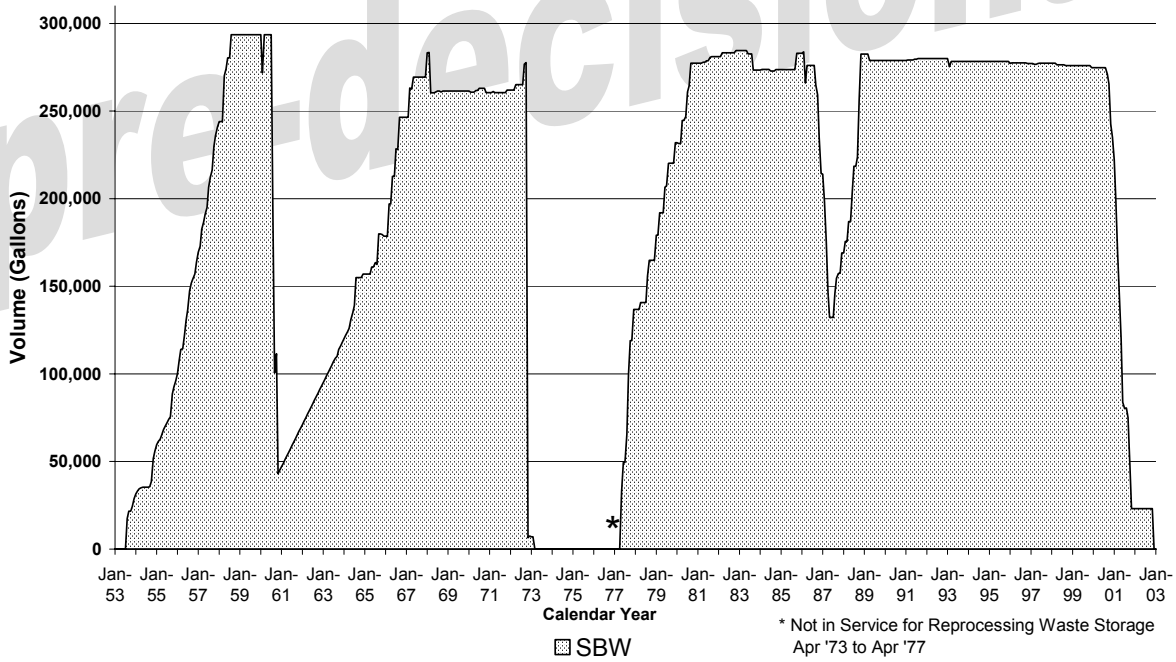

Figure 2-5. Historical volumes of waste stored in Tank WM-181.

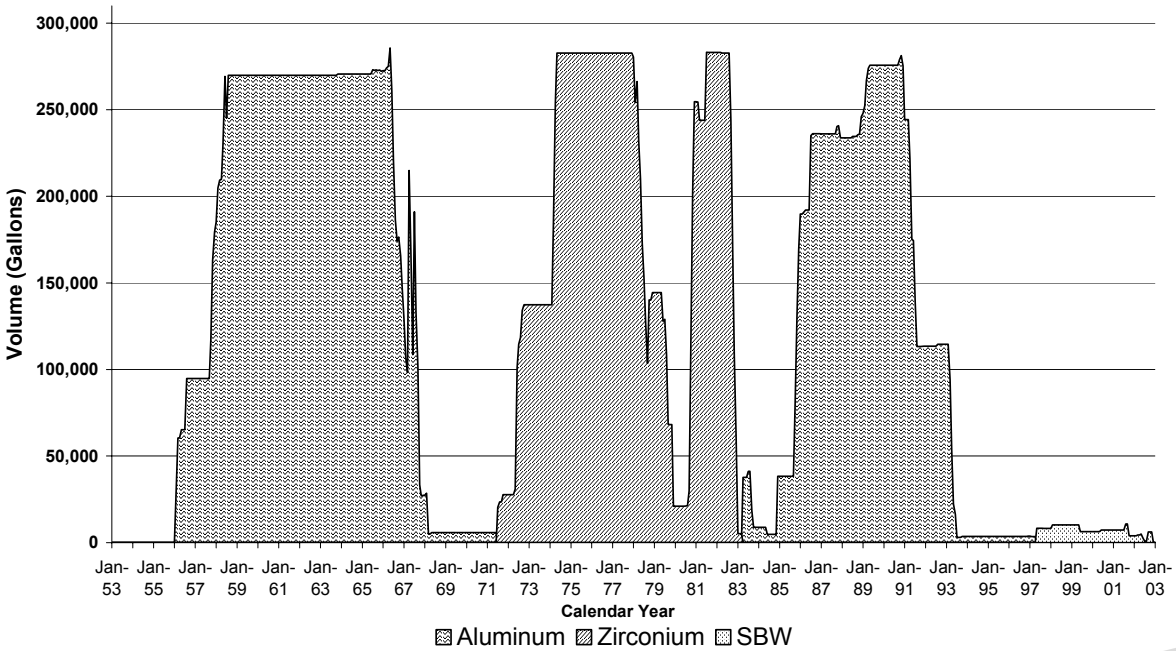

Figure 2-6. Historical volumes of waste stored in Tank WM-182.

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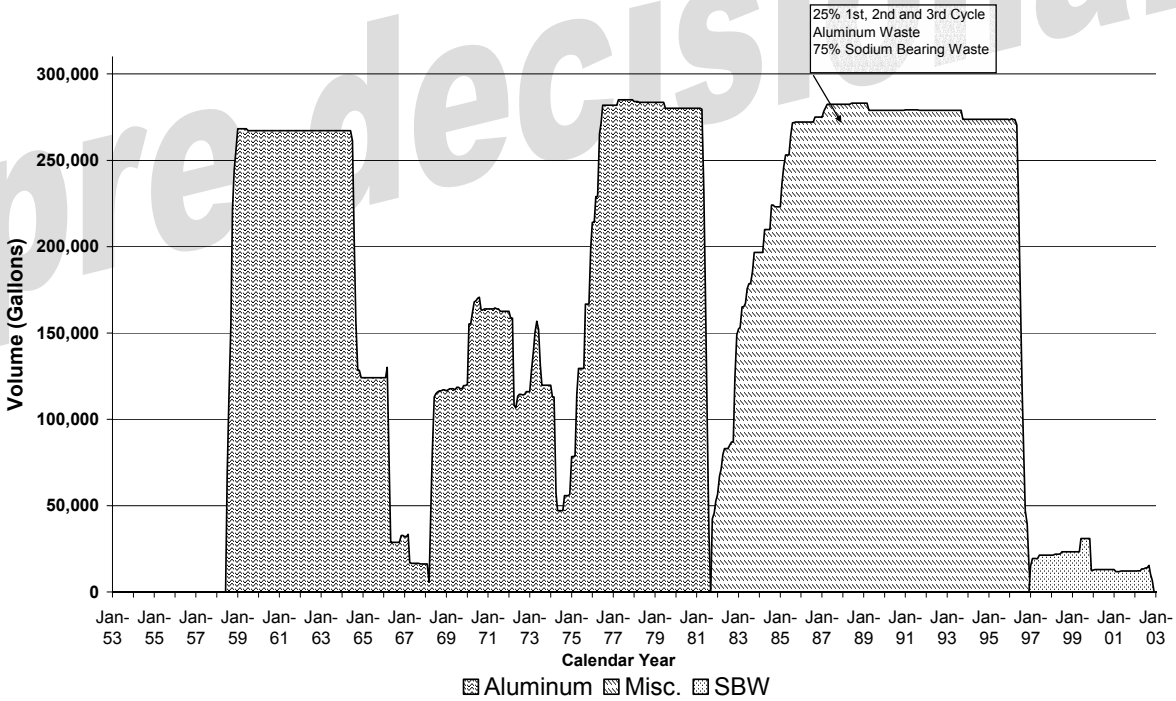

Figure 2-7. Historical volumes of waste stored in Tank WM-183.

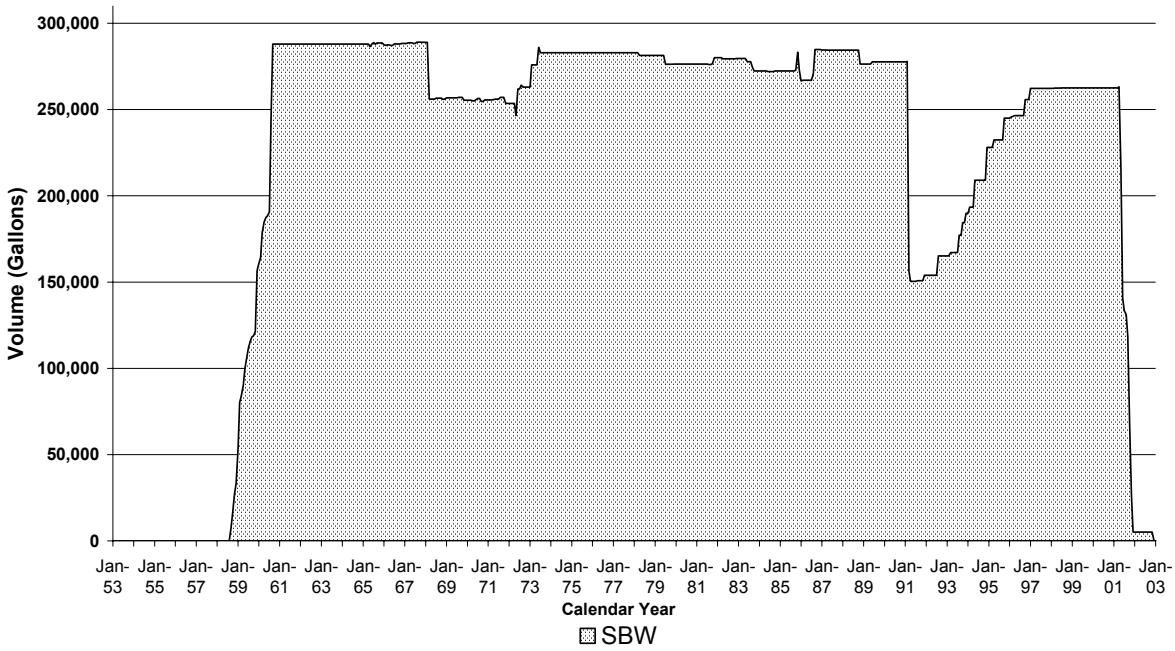

Figure 2-8. Historical volumes of waste stored in Tank WM-184.

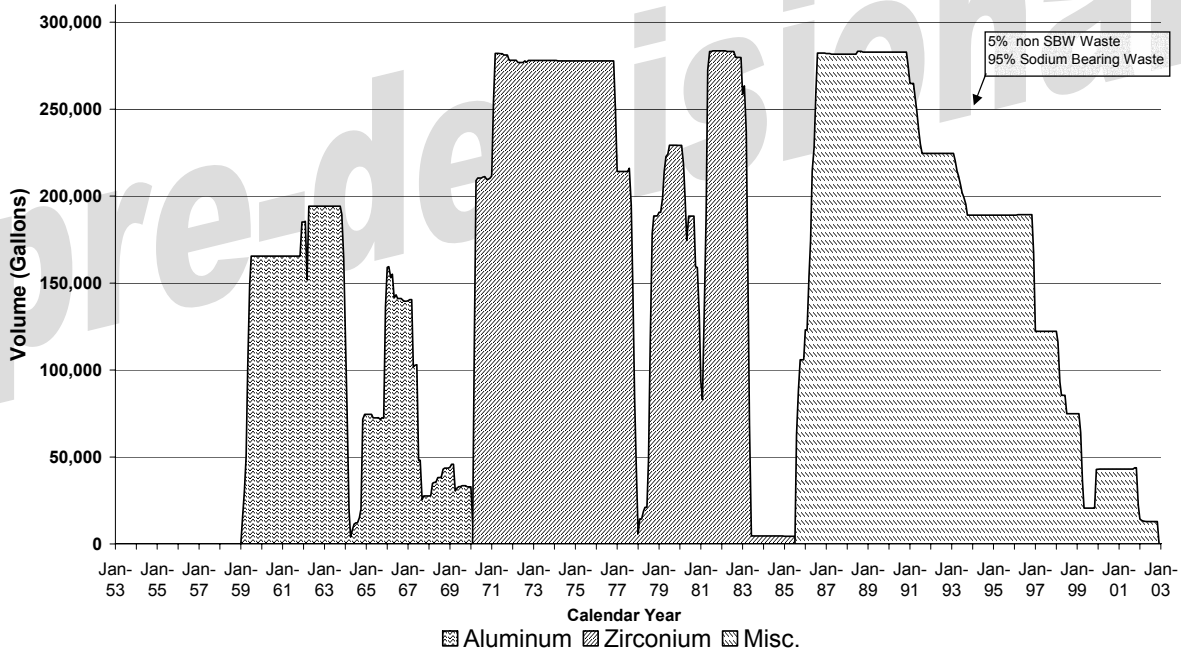

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Figure 2-9. Historical volumes of waste stored in Tank WM-185.

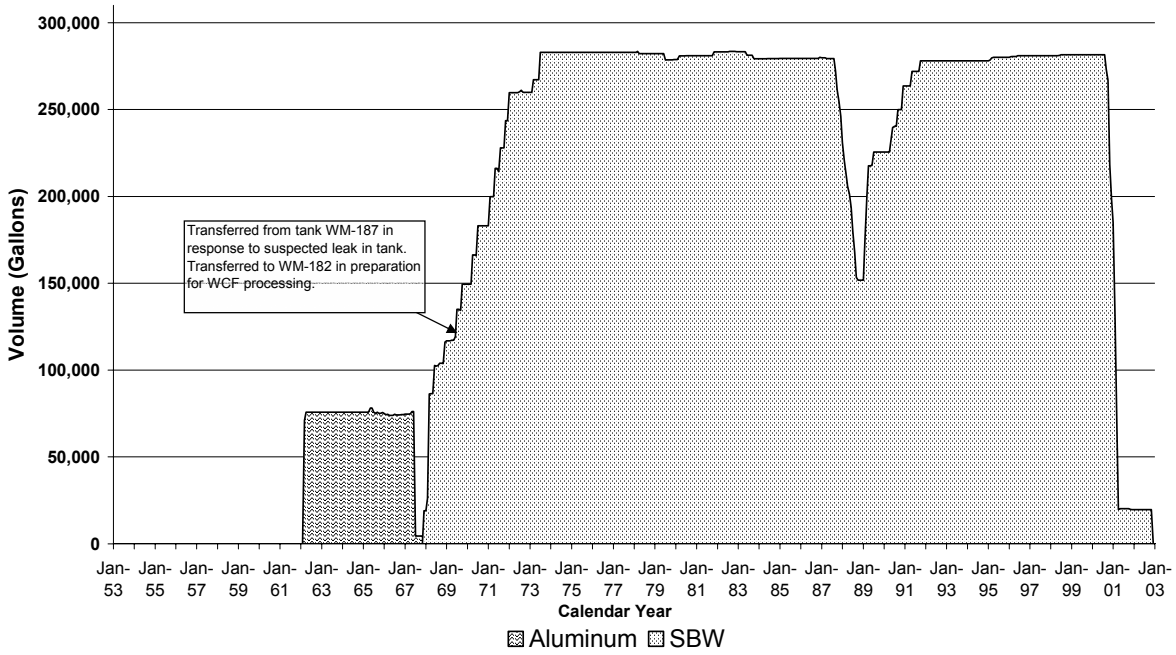

Figure 2-10. Historical volumes of waste stored in Tank WM-186.

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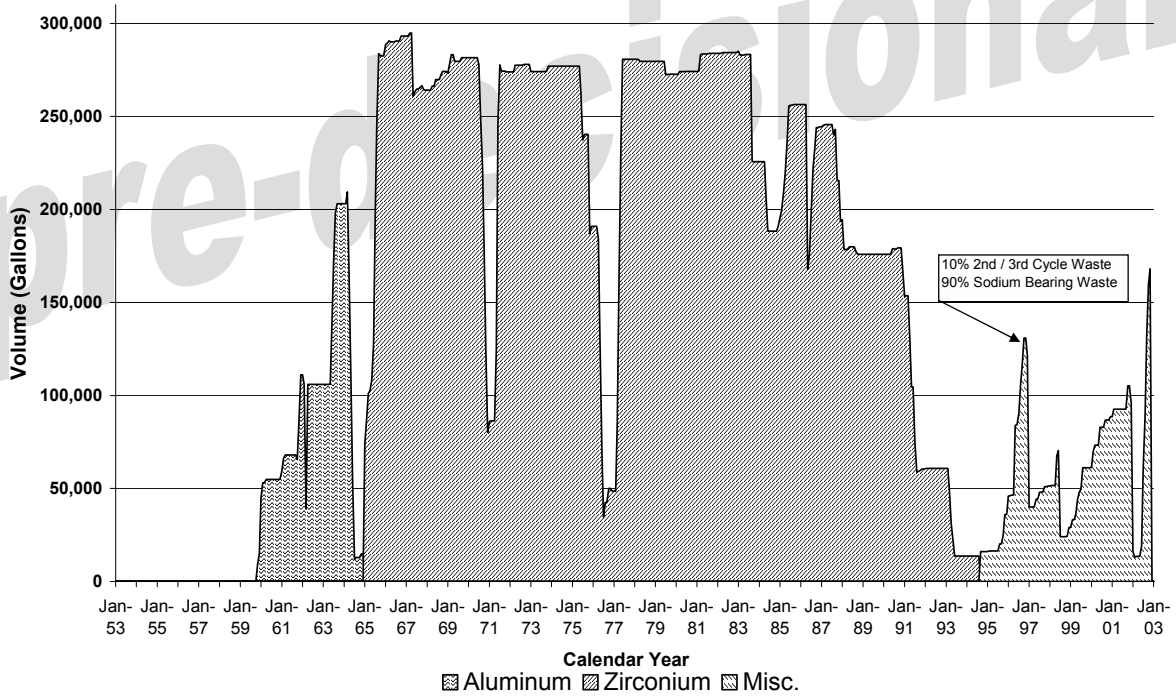

Figure 2-11. Historical volumes of waste stored in Tank WM-187.

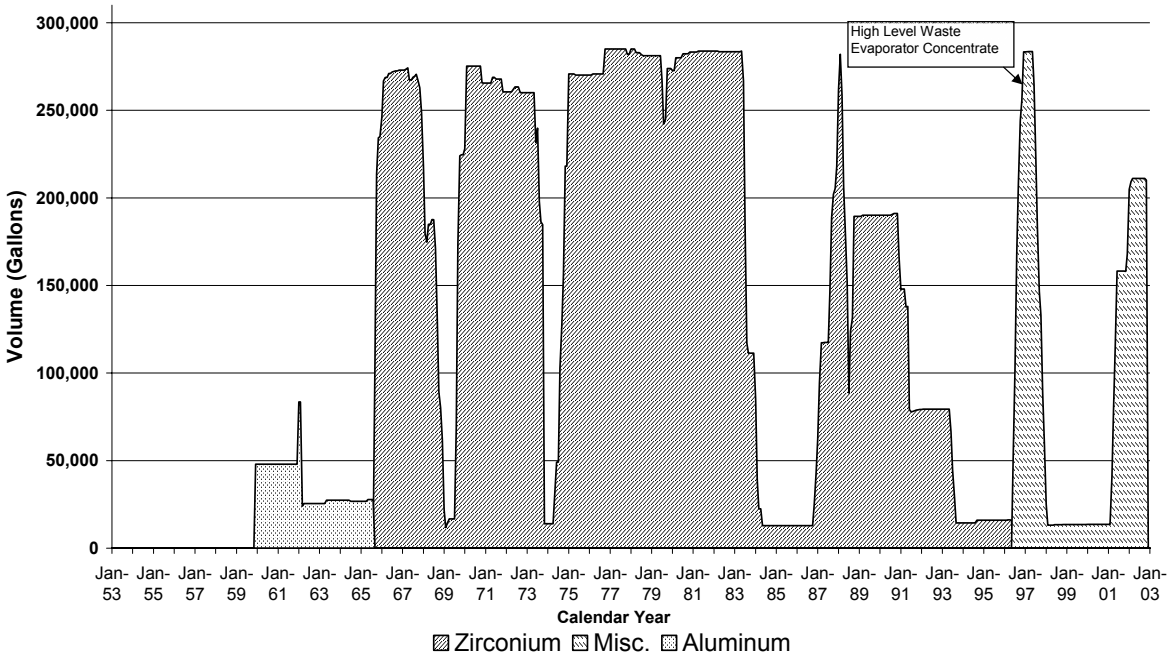

Figure 2-12. Historical volumes of waste stored in Tank WM-188.

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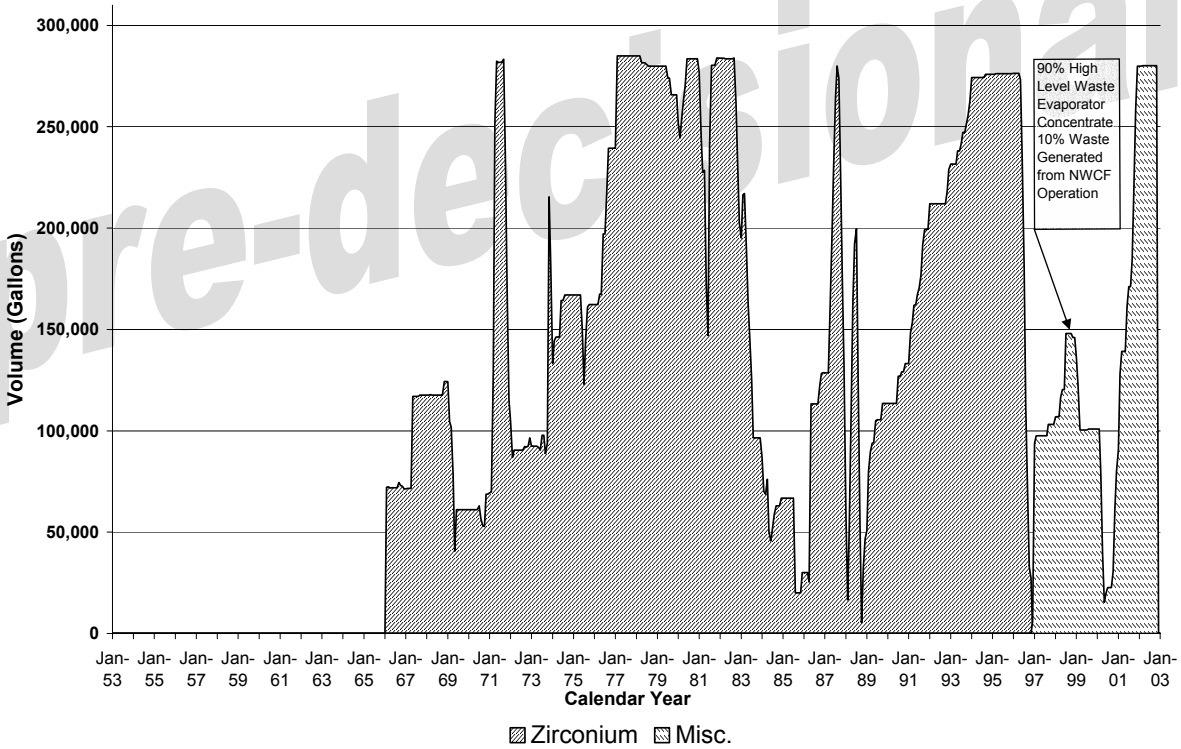

Figure 2-13. Historical volumes of waste stored in Tank WM-189.

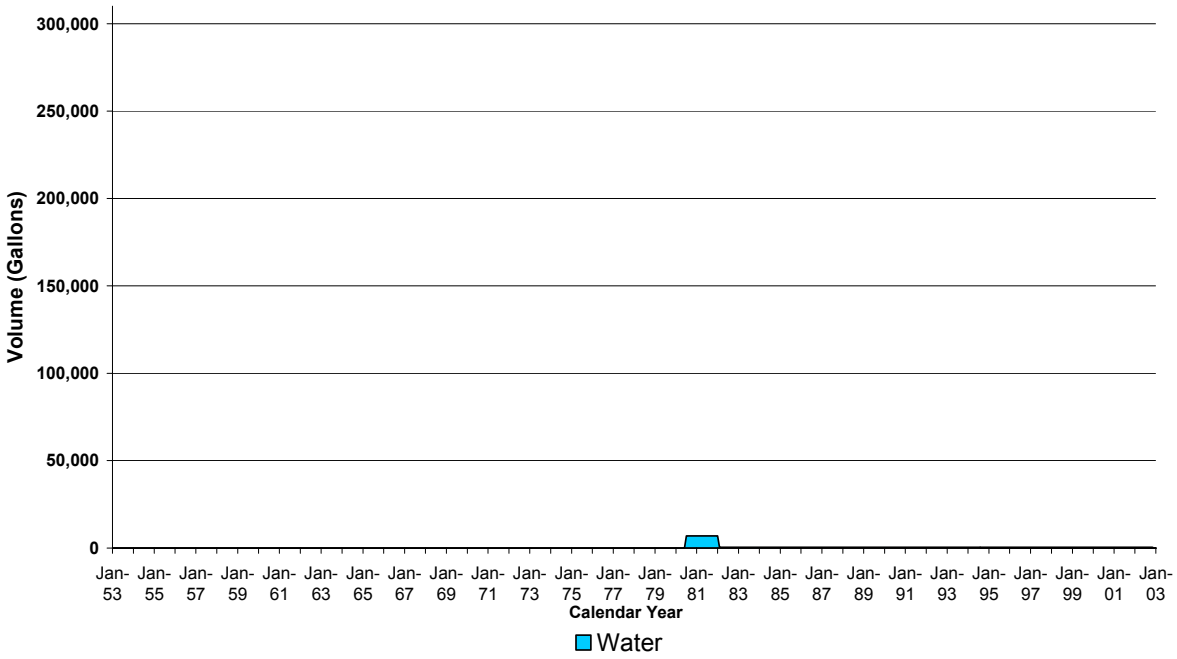

Figure 2-14. Historical volumes of waste stored in Tank WM-190.

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Table 2-5. Tank volumes as of December 31, 2002.

Tank	Volume[a] (gal)	Tank	Volume[a] (gal)
WM-180	276,000	WM-186	19,700
WM-181	23,000	WM-187	229,000
WM-182	6,400	WM-188	210,100
WM-183	4,500	WM-189	280,100
WM-184	5,100	WM-190	500
WM-185	12,900	**Total**	**1,067,300**

a. Source: Letter from J. H. Valentine, INEEL, to Brian R. Monson, DEQ, 2003, "Contract No. DE-AC07-99ID13727-Status of Consent Order Activities," CCN 39424, January 28.

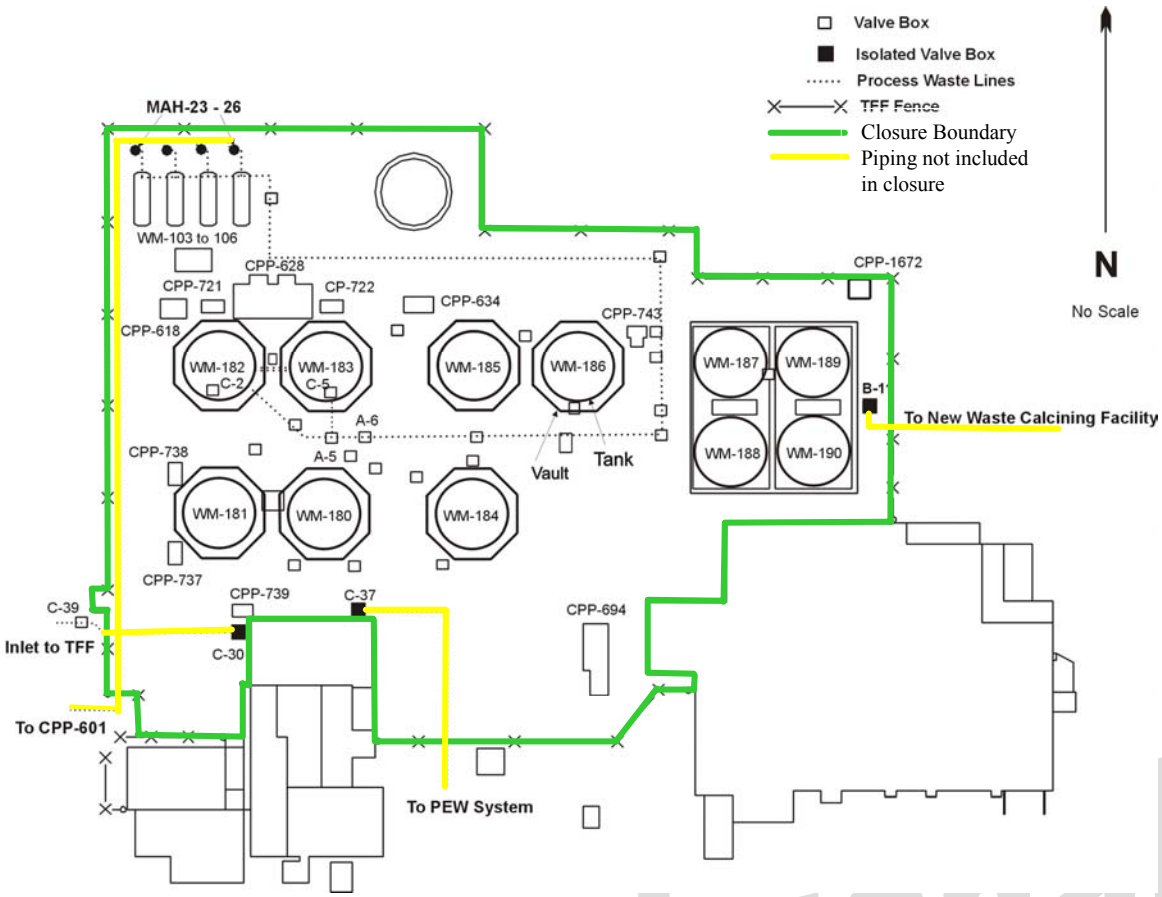

Figure 2-15. The TFF showing general closure boundaries.

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surrounding the TFF. The contaminated soil will be addressed by the CERCLA program.

2.5 Closure Process

The closure process for each tank involves three stages: 1) site preparation, 2) tank decontamination and sampling, and 3) grouting.

2.5.1 Site Preparation

Site preparation will include moving support buildings to the work site, designing and constructing specialized equipment, and installing utilities. A brief description of these preparations is provided in the following subsections.

2.5.1.1 Support Structures. Temporary support structures (trailers) will be placed at approved locations outside of the TFF fence. The control trailer will provide office space for project management and other personnel functions. In the control trailer, workstations with video monitors will allow remote monitoring to assess closure progress and collect data. One of the trailers will be used as a support area for construction and sampling personnel. Electrical power will be installed to these structures as required.

2.5.1.2 Temporary Enclosures. Specially-designed enclosures will be constructed and installed over the tank and vault risers to allow safe access to equipment used during closure. A typical enclosure design is shown installed over a tank riser in Figure 2-16.

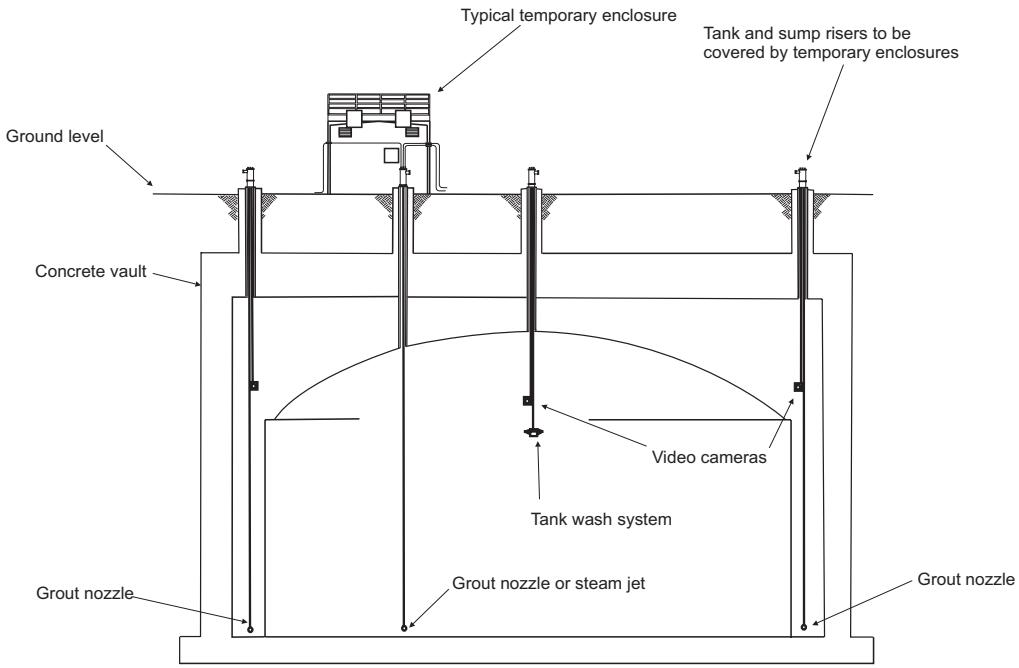

Figure 2-16. Cross section of a typical tank and vault showing an enclosure, tank wash system, and video cameras (drawing not to scale).

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Enclosures will likely be installed over the tank vault risers in locations such as those shown in Figure 2-17. The tank risers will be the primary access points to the insides of the tanks and vaults for decontamination, monitoring, and sampling equipment. The enclosures will be equipped with ventilation and high-efficiency particulate air (HEPA) filters to provide containment. The enclosures will be connected to electrical power to operate ventilation systems. Process waste and steam lines will pass through the enclosures and tank risers to the tanks. The enclosures are designed with roof hatches directly over the tank risers to allow placement of equipment. As needed, a video camera may be installed in each tank and vault enclosure to monitor activities and collect data.

2.5.1.3 Temporary Ventilation System. If needed, a temporary, skid-mounted VOG system will be installed to maintain negative pressure in the tanks during closure, minimizing the possibility of contaminant release. The temporary system will bypass the existing TFF ventilation system. The temporary system will connect to tend of he TFF VOG lines in the vicinity of the tanks being closed and will be used as necessary until final grouting is complete. A simplified airflow will be established by the VOG system, which contains HEPA filters, delivering air to the pressure-relief piping at the TFF. Then, the air will be discharged to the atmosphere from the main stack at INTEC.

2.5.1.4 Steam Ejector Jet System. The steam ejector jet system, designed to transfer liquid to and from the TFF tanks, will be modified to allow as much of the liquid waste in the tanks as possible to be removed. The jets are connected to the INTEC high-pressure steam system through the tank risers and are currently fixed in place close to the floor of the tanks. The high-pressure, high-velocity steam induces a vacuum (suction) across the jet throat. Liquid waste enters the suction head, is entrained and

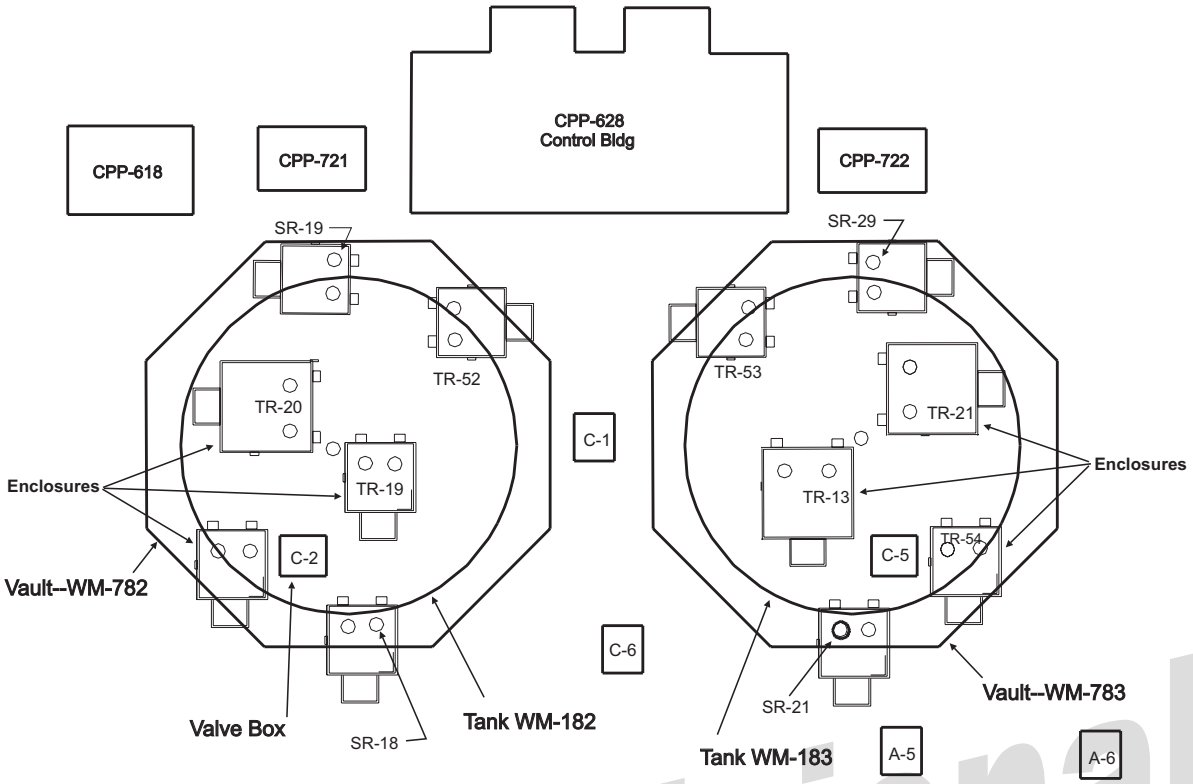

Figure 2-17. Temporary enclosures installed over the tank and sump risers (drawing not to scale).

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accelerated by the jet of steam, and discharged through the jet throat to process waste piping.

The steam jets are currently fixed at a height of 3 to 12 in. (7 to 31 cm) above the tank floors, which would leave a significant volume of waste in the bottoms of the tanks even when pumped to the lowest possible level. Consequently, modification of the jets is required to remove more of the waste than is currently possible. The piping for one of the ejectors in each tank will be modified to extend the ejector suction head to within 1 in. (3 cm) of the tank floor. The other ejector may be removed from the tank to allow access through the riser for other equipment necessary for closure activities.

2.5.1.5 Tank Wash System. A tank wash system, designed to clean waste residual from the interior walls of the tanks, will be installed (Figure 2-16). The system includes a wash ball and/or directional nozzles to deliver a high-pressure stream of water from a nearby decontamination (demineralized) water holding tank. When needed, directional nozzles can be used to move residuals toward the steam jet. A pump will be installed to deliver high-pressure water from the supply tank through the tank risers to the wash ball. The wash ball will be lowered into the tank and deliver a high-pressure stream of water toward the walls of the tank to wash down any residual on the walls and agitate the tank heel solids. The effectiveness of the wash-ball and directional nozzle systems was evaluated during mock-up testing (INEEL 2001a).

The mockup demonstrated that the majority of solids in a tank representative of a TFF tank could be removed with a combination of a wash-ball and directional nozzle system to agitate the solids and

a steam jet system to remove the agitated mixture from the system. The combination of these systems removed 99.2% by volume of the solids in the mockup tank (INEEL 2001a).

A proof-of-process demonstration for the decontamination of Tanks WM-182 and WM-183 and their associated components (valve boxes, piping, etc.) was conducted in 2002. The initial data from this demonstration indicate that the performance objectives defined in this closure plan can be met. Detailed analysis of the data from the demonstration will be incorporated into the Tier 2 closure plan once final data are available.

2.5.1.6 Monitoring Equipment. Closure activities will be monitored using several techniques. Video cameras will be used inside the tanks to monitor the decontamination operation and effectiveness (Figure 2-16). After the tanks are emptied of the bulk solid and liquid wastes and before the wall is decontaminated with the wash system, the tank camera will be lowered into the tank through the risers. Video displays for each camera will be located at the video control workstations in the control trailer, allowing remote monitoring and avoiding worker exposure to radiological or hazardous constituents. Two data displays will be available to operators and project personnel in the control trailer for monitoring process data.

2.5.1.7 Grout Supply Station. A station to supply grout to the tanks will consist of a pump, split flow valves, supply lines, grout delivery system, and two grout nozzles. When decontamination of the tanks is complete and grouting is ready to commence, the nozzles will be inserted through risers closest to the tank walls.

2.5.1.8 Utilities. Demineralized water will be used for decontamination. Electrical power will be routed to the enclosures, grout delivery pump, temporary VOG system, support structures, and auxiliary equipment such as lighting and power tools. Power will also be provided to the control and sampling support trailers.

2.5.1.9 Tank Isolation and Ancillary System Decontamination. Tank isolation and decontamination preparation activities include valve box decontamination, process line isolation, pipe encasement decontamination, vault sump decontamination, VOG system isolation, tank access, and non-process waste line isolation. The following discussion outlines the steps required to isolate a tank from the rest of the TFF and describes the decontamination of ancillary systems. The steps were developed by the INEEL HLW Program and are documented in the *Conceptual Design Report, INTEC Tank Farm Facility Closure* (INEEL 2000b). Tank isolation and decontamination steps will be finalized during Title II design.

The washing and cleaning sequence for the piping and equipment has been segregated into stages based on a logical progression that ensures decontaminated areas will not be re-contaminated by subsequent operations. The decontamination sequence may change based on field conditions. Decontamination sequence changes would not jeopardize the closure performance standards, would be considered minor deviations, and would be noted by the independent professional engineer (PE) during certification. Therefore, sequence changes would not require a modification to the closure plan.

2.5.1.10 Valve Box Decontamination. Isolation of a tank will begin with decontamination of selected valve boxes. Decontamination equipment to be used in the valve boxes will be connected to the demineralized water source. The inside surfaces of each valve box will be washed and the decontamination fluids will be allowed to drain through drains in the valve boxes to the vault sumps. This process will also flush the drain lines, vault sump, and vault floor. The steam jet pumps in each sump will be used to pump decontamination fluids out of the tank. Samples of decontamination solution will be collected from the vault sumps before grouting. The data obtained from final decontamination will be included in the comparison to action levels.

2.5.1.11 Pipe Encasement Decontamination. The stainless-steel-lined concrete encasements that provide secondary containment for process waste lines will be

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decontaminated. Each encasement will be rinsed with decontamination solution. The decontamination fluids will be allowed to drain through the 1-in. drain lines to the vault sumps to decontaminate the drain lines. The residual remaining in the sumps will be sampled, analyzed, and compared to action levels. Decontamination fluids that accumulate in the sumps of each vault will be transferred with the steam jets to the HLLW evaporator.

The pipe encasement decontamination also will allow for decontamination of the tank vault floor. Historically, the only way that liquid waste could have entered the vaults is from valve or pipe leaks, which were collected in the encasements that drain to the vault sump. The volume of liquid released to the vault sump and, subsequently, to the vault floor was minimal. Level-detection instrumentation located in the vault sump alerted operators to leaks.

During closure, decontamination fluid will be introduced into the encasement and will flow onto the vault floor and into the vault sump, following the path by which waste may have previously entered the tank vault. The rinsing sequence will be performed with a sufficient volume to ensure adequate vault floor coverage. In this way, these flushes will decontaminate both the encasements and the vault floor. The decontamination fluid will be pumped out as previously described and samples will be collected. Sampling results will be indicative of the residual left in the vault sump from the encasements and the tank vault.

2.5.1.12 Vault Sumps. Lines leading from the vault sumps into the tanks will be decontaminated using the steam jets. Waste lines in each of the vault sumps will be flushed and emptied into the respective tanks. Any remaining lines in the vault sumps used for transfer of liquids to the HLLW evaporator will be decontaminated later in the closure process. These lines will be terminated at the appropriate valve box. The residual decontamination solution from these sumps will be sampled for comparison to action levels. After decontamination of the vault liquid removal lines is complete, the valves on the steam supply lines to the sump jets will be administratively isolated.

2.5.1.13 Process Waste Line Isolation. Process waste lines will be isolated in the valve boxes. If needed, split-flow valve cartridges may be installed to replace various valves on process waste lines to enable grout to be placed in the lines leading to the tanks while allowing decontamination and subsequent grouting of lines leading to other portions of the TFF. Process waste lines will be rinsed with decontamination fluid, which will be drained to the tanks, depending upon which system is being decontaminated.

Split-flow valve cartridges are designed to isolate pipelines without having to manually or remotely cut and remove pipe sections in contaminated areas. A split-flow valve cartridge replaces the ball valve components with a separating plate. Use of these cartridges limits worker exposure and minimizes pipe cutting and welding in hazardous environments.

Flushing with demineralized water has been used successfully to decontaminate piping in the TFF, remove residual waste, reduce radiation fields, and limit the potential for airborne radioactivity. Historically, decontamination of the lines has been performed during maintenance and repair work on the systems (i.e., valve replacement or repair that requires line welding). Water flushing proved effective for the lines as demonstrated by visual inspection of the lines after cutting in preparation for welding. The lines were observed to be free of liquids and loose solids during inspections (Demmer 1996).

Aqueous nitric acid also has been used for decontamination during waste transfers through the lines (Demmer 1996). Nitric acid is the most commonly used decontamination chemical at INTEC. Many of the processes at INTEC contain solid material that is soluble in nitric acid, and the waste itself is nitric acid-based. During transfer, nitric acid transfer solutions remove solids in the lines and valves. After waste transferring containing solids in solution or suspension, the piping was flushed with water. Flushing the pipelines is intended to remove liquids and any loose solids remaining from waste transfers.

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2.5.2 Tank Decontamination and Sampling

New or existing steam jets in the tanks will be used to remove the bulk liquid wastes from the tanks. The jets may be lowered to ensure they will pump out as much of the liquid waste as possible to an operational TFF tank, leaving a tank heel. Engineering studies prepared during the conceptual design phase (INEEL 2000b) have indicated that the steam jets will leave the tank heel at a depth of 1 in (3 cm).

After removing the bulk liquids, the tank wash and video systems will be installed in the tank risers. The steam jet in each tank will be operated concurrently with the wash system to remove as much of the waste as possible. The steam jets are expected to effectively remove hazardous constituents from the heel (INEEL 2001a). The video system will be used to evaluate and record the effectiveness of the tank wall decontamination. In addition to removing contaminants from the tank walls, the tank washing sequence is designed to provide incidental pH adjustment of the residuals. The final pH in the decontaminated tank residuals will be confirmed to be greater than 2.0 but less than 12.5.

Using steam jets in each tank to remove thousands of gallons of decontamination fluid from the tank will effectively decontaminate the jets. They will be left in place at the end of decontamination. If samples from the tank liquids meet the action levels, it will be assumed that the steam jet is also appropriately decontaminated.

Several sampling events are planned during closure activities. The tank heel will be sampled with a remote-sampling device developed during closure design. Decontamination solutions from the valve boxes, vaults sumps, and cooling lines will be sampled.

The sampling and analysis approach and procedures for Phase 1 are defined in the *Sampling and Analysis Plan for the Post-Decontamination Characterization of the WM-182 and WM-183 Tank Residuals* (Portage Environmental 2002). Similar plans will be developed for the remaining phases of TFF closure. The purpose of sampling is to

- Determine that hazardous wastes are not left in place in the TFF tank systems. Wastes presently in the tanks are toxic and corrosive. Therefore, the mean characteristic of the post-decontamination residues remaining throughout the TFF system must be shown to be less than the toxicity characteristic shown in Table 1 of 40 CFR 261.24 (2002), and have a pH between 2.0 and 12.5.

- Determine whether or not the decontamination of the TFF tank systems resulted in concentrations of tank system residuals that meet HWMA/RCRA clean-closure levels specified in the closure plan.

- Determine whether or not the residuals remaining in TFF tank systems have radionuclide activities that meet DOE Order 435.1 radioactive waste management requirements for closure of the facility.

Post-decontamination samples from tank residuals, vault sumps, and rinsates from the cooling coil will be collected and analyzed (for a specific group of parameters) to determine whether or not HWMA/RCRA and DOE requirements have been met.

Because the sumps are the lowest points within the vault, decontamination of the piping encasements will allow decontamination fluid to flow onto the vault floor and decontaminate the floor. Samples will be collected after decontamination. After the vault sumps are emptied and the vault liquid removal lines have been decontaminated, the steam jets and lines for the sumps will be disconnected.

During tank washing, a radiation detection instrument will be used to measure radiation levels of waste removed from the tanks. As the concentrations of radionuclides are reduced and begin to stabilize, the decontamination will cease. The correlation of removal efficiency between radionuclides and metals in the tank will be sufficient to determine when decontamination efficiency has been maximized, indicating that

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sampling for comparison to action levels may begin.

Data collected during closure will be used in the evaluation of action levels, specifically looking at the radionuclides ^{129}I, ^{99}Tc, ^{90}Sr, ^{14}C, and ^{137}Cs. Section 6 provides additional detail on the evaluation process. Additional plans for subsequent phases will be based on these data.

2.5.3 Grouting

After tank isolation activities are complete and a determination has been made regarding the effectiveness of decontamination, and when decisions for DOE closure and HWMA/RCRA closure have been finalized, final heel management and tank grouting will begin. At that time, the tank vaults will be isolated and final grouting of the tanks, vaults, and piping will be performed.

2.5.3.1 Grout Design. The *Conceptual Design Report, INTEC Tank Farm Facility Closure* (INEEL 2000b) provides a detailed description of the design, testing, and evaluation process used to determine the appropriate grout design for the tank closure. The grout must be able to provide long-term stability of the waste under the expected disposal conditions and meet the requirements of 10 CFR 61 (2003). These requirements include

- Prevent excessive subsidence, settlement, or deformation
- Minimize water infiltration
- Prevent radionuclide release due to disintegration of the waste form
- Minimize the likelihood of waste intrusion.

The grout also provides a mechanical method for removing residual waste by repositioning the heel (see Section 2.5.3.2) so that it can be removed with the steam jets. This requires the grout to have the consistency and density to displace the waste.

The grout mixture to be used for the closure was initially tested as part of the conceptual design (INEEL 2000b) and then in the tank mockup testing (INEEL 2001a). Mixtures will differ depending on their use (closure of the pipes, tank, or vault). In general, the grout will consist of the following ingredients in differing proportions:

- Cement (Type I/II)
- Fly ash and water
- Cementious material
- Sand and gravel
- Water reducer.

A chemical reducing agent such as iron sulfate will be added to the grout to ensure that the grout has a low oxidation potential.

2.5.3.2 Initial Grouting. The initial grouting process is designed to remove additional residual heel left in the tanks after decontamination. The initial placement of the grout and concurrent operation of the steam jet is designed to remove as much heel as possible. Grouting will be performed using the grout nozzles in a predetermined sequence. As the grout is placed, the residual heel (liquid and solid) will be displaced toward the steam jet and transferred through process waste piping to an operational TFF tank. After the initial placement, the remaining grout will be placed in layers into the tank. Video inspection will be used to determine whether or not free liquids remain and if additional absorbent (such as dry grout or other absorbent) is necessary.

2.5.3.3 Final Grouting. The final grouting will include the pipe encasements between the valve boxes and the tank vaults. Grout will be pumped through the encasement covers previously installed in the valve boxes. This process will grout the 1-in. encasement drain lines. Vault instrumentation lines will be filled with grout by removing the temporary caps installed in the TFF Control House. The lines will then be permanently capped. Grout hoses will be inserted in the vault risers, connected to the grout supply, and grouted. After the vaults have been filled, the vault risers will be filled. The process waste lines will be grouted, and the waste lines in the condenser pits will also be grouted. Each grouted line will be permanently capped.

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Grouting of the tanks and VOG lines will then be completed. At this stage, only the initial grout placements are present in the tanks. The remaining tank volumes will be grouted in lifts until the tanks are full. Video surveillance equipment and lighting will be used to observe grout placement. This action will also grout the overflow lines between the tanks. The VOG lines and condenser pits will be grouted. Grout will be pumped through the VOG lines until it enters the tank risers. After the remaining tank voids and the VOG lines are filled with grout, the VOG lines will be permanently capped. Any remaining voids in the tank risers will be filled with grout. These lines and the tank risers will then be permanently capped.

The cooling coil lines for each tank will be grouted by connecting the grouting equipment to the supply (60 lines for each tank). Grout will be pumped into each line until it exits the return end or until the line no longer accepts grout.

2.6 Schedule

Closure of the TFF tanks will be performed in five phases as shown in Figure 2-18. Tanks WM-182 and WM-183 will be closed in Phase 1, as shown in Table 2-6, and serve as a proof-of-process demonstration for the remaining phases. A Tier 2 document will be prepared for and approved by the Field Element Manager before initiating each of the five phases. As each closure phase is initiated and the associated tanks are taken out of service, the remaining tanks in the TFF will remain open. The TFF will continue to operate until 2012 while the closure phases proceed and the remedial investigation and feasibility study (RI/FS) for Operable Unit (OU) 3-14, which addresses releases to the surrounding soils at the TFF, is completed. As closure phases are accomplished and additional data is evaluated, closure processes may be changed accordingly.

2.7 Schedule Prerequisites

The key prerequisites for TFF closure activities to begin are administrative and engineering requirements. The administrative prerequisites are related to approval of required plans and documentation. Engineering requirements include those physical aspects of the projects that must be accomplished before closure activities can begin. The key administrative and engineering prerequisites, according to DOE Order 435.1 (DOE 2001a), DOE Manual 435.1-1 (DOE 2001b), and DOE Guide 435.1-1 (DOE 1999a), are the

- Tier 1 Closure Plan. In accordance with DOE Order 435.1, the appropriate Deputy Assistant Secretary within the Office of EM must approve this Tier 1 Closure Plan. An Authorization to Proceed is required before any irreversible closure action can occur. The Authorization to Proceed represents DOE-HQ approval of the Tier 1 Closure Plan and other closure documents as adequately representing and assessing the planned closure action.

- Tier 2 Closure Plan. In accordance with DOE Order 435.1, the Field Element Manager, or designee, will provide detailed information related to specific unit closure actions. These actions will be bounded by the information contained in the Tier 1 Closure Plan.

- HWMA/RCRA Closure Plan. The HWMA/RCRA closure plan for the various phases of closure must be approved by DEQ.

- PA. The PA submitted as part of the review of this Tier 1 Closure Plan must demonstrate that the proposed closure action meets the performance objectives required by DOE Order 435.1.

- CA. The CA submitted as part of the review of this Tier 1 Closure Plan must provide a reasonably conservative assessment of the cumulative impacts from the proposed closure action and all other sources of radioactive contamination that could interact with the closure actions and affect the dose to the public.

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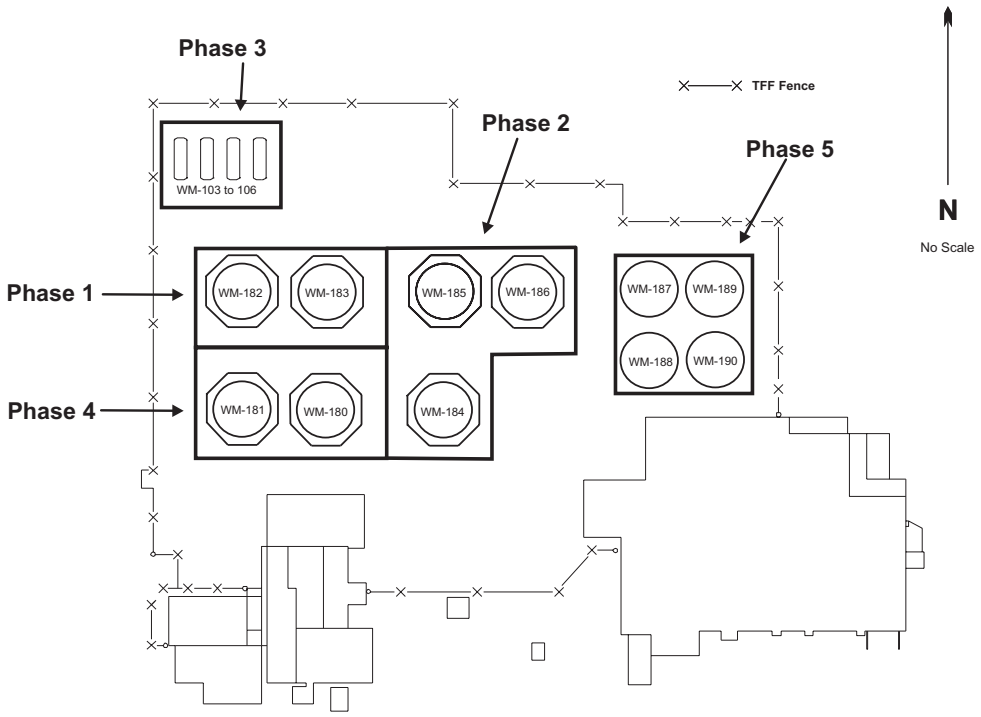

Figure 2-18. TFF proposed closure phases.

Table 2-6. Schedule for the TFF closure.

Task Title	Approval or Completion
Tier 1 Closure Plan	5/2003
Composite Analysis	5/2003
Performance Assessment	5/2003
Waste Incidental to Reprocessing Determination	5/2003
Tier 2 Closure Plan for WM-182 and WM-183	6/2003
Contingent Landfill Closure and Post Closure Plan for WM-182 and WM-183	5/2002
Addendum to SAR-107	6/2003
High-Level Waste and Facility Disposition Record of Decision	
Closure of Phase 1[a] for WM-182 and WM-183	9/2004
Phase 2, Tanks WM-184, WM-185, and WM-186	2002–2007
Phase 3, Tanks WM-103, WM-104, WM-105, and WM-106	2004–2011
Phase 4, Tanks WM-180 and WM-181	2007–2013
Phase 5, Tanks WM-187, WM-188, WM-189, and WM-190	2011–2016

a. All phases will include a HWMA/RCRA closure plan, a Tier 2 closure plan, and a sampling and analysis plan.

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- WIR determination. The WIR determination for the residuals remaining in the TFF at the time of closure must be approved before stabilization of the residuals. Certain waste streams produced during the generation of HLW waste may be determined to be TRU or LLW through the WIR process.

- Title II design. The Title II design phase must be completed, which will finalize closure activities and sequences.

- EIS Record of Decision (ROD) (per the National Environmental Policy Act [NEPA] [42 USC 4321–4347, 1969]). The final HLW and Facilities Disposition EIS ROD will be approved.

- Safety analysis reports. Safety authorization basis for evaluation of closure activities.

- Activity-based review. In accordance with DOE Order 425.1C (DOE 2003) and the associated contractor implementing procedures, an activity-based review will be performed for each stage of the closure process to ensure the activity proceeds with minimum risk. Equipment to be used for the decontamination, sampling, and grouting will be functionally-tested as required before being installed in the tanks. This testing will involve the equipment to be installed in the tanks, the control trailer that will operate the cleaning equipment, and the utility equipment that will supply media to the tank equipment. System operability testing is not feasible because introduction of liquid into the tanks would initiate the closure process.

- Liquid storage. Liquids from the tanks and from decontamination will be transferred to Tank WM-187 before processing in the HLLW evaporator. Space must be available in Tank WM-187 before initiating decontamination of a tank.

- Liquid processing. The HLLW evaporator will process liquids stored in Tank WM-187. The HLLW evaporator must be operational to ensure space will be available in Tank WM-187.

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3. INTEGRATION WITH OTHER REGULATORY REQUIREMENTS

During the process of meeting DOE radioactive waste and HWMA/RCRA hazardous waste closure requirements, other ongoing INTEC and TFF actions may affect TFF closure activities. These actions include the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup of the TFF soils and decisions made in accordance with NEPA requirements (42 USC 4321–4347, 1969) in the *Idaho High-Level-Waste and Facilities Disposition Environmental Impact Statement* (DOE 2002). Other regulatory requirements that may impact this closure include provisions of the Clean Water Act (33 USC 1251 et seq. 1948), Safe Drinking Water Act (42 USC 300f et seq., 1974), RCRA (42 USC 6901 et seq., 1976), HWMA (State of Idaho 1983), National Historic Preservation Act (16 USC 470 et seq., 1966), Clean Air Act (42 USC 7401–7671, 1955), and the Toxic Substances Control Act (TSCA) (15 USC 2601–2671, 1976). Finally, facility documents also have been developed that may impact this closure.

3.1 Federal Facility Agreement and Consent Order

Integration of CERCLA actions is important to the TFF closure. The RCRA closure of a TFF tank system requires investigation of associated contaminated soils. The TFF contaminated soils will be investigated in accordance with CERCLA requirements as governed by the Federal Facility Agreement and Consent Order (FFA/CO) (IDHW, Environmental Protection Agency [EPA], and DOE-ID 1991) for the entire TFF. Investigation of the TFF soils will be addressed in the OU 3-14 RI/FS.

In fiscal year 2003, new information affecting the OU 3-14 scope and the Tank Farm interim action (DOE-ID 1999) occurred. The Agreement to Resolve Dispute (INEEL 2003a), related to the December 4, 2002, Notice of Violation (EPA 2002), requires separating out the non-Tank Farm soil components (sites CPP-23, CPP-61, CPP-81, CPP-82) from the OU 3-14 RI/FS and revising the OU 3-14 data quality objectives as a modification to the existing OU 3-14 RI/FS Work Plan (DOE-ID 2000a). The revised data quality objectives will identify any data gaps needed to support and perform an evaluation of options for implementing an early permanent remedy and propose a recommendation for the feasibly of accelerating the OU 3-14 Record of Decision.

The Tank Farm interim action was designed to restrict potential direct exposure from the soils within the TFF and minimize potential leaching and transport of contaminants to the perched water or Snake River Plain Aquifer (SRPA) (DOE-ID 2000b). These goals will be accomplished by completing all work outside the Tank Farm fence and installing an infiltration barrier over soil release sites CPP-28, CPP-31, and CPP-79 inside the Tank Farm fence in accordance with the Agreement to Resolve Dispute (INEEL 2003a). The interim action design will be implemented in two phases (DOE-ID 2000b, INEEL 2003a):

- **Phase I (outside the Tank Farm fence):**
  - **Storm Water Drainage System Upgrade**. The storm water drainage system will be upgraded around the TFF and out to the discharge point. This upgrade includes constructing, grading, and lining new and existing ditches with concrete; installing a trench drain, lift station, and manholes; and replacing existing culverts with larger culverts to accommodate the expected increase in storm water flow. Also included are constructing concrete headwalls and endwalls, as necessary, throughout the lined drainage system.
  - **Storm Water Evaporation Pond**. A lined storm water evaporation pond will be constructed outside the INTEC fence to collect storm water runoff that currently discharges into environmentally controlled area 37 A.

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- **Phase II (inside the Tank Farm fence):**
  - **Infiltration Barrier**. An infiltration barrier (concrete, asphalt, high-density polyethylene, polyurea, or temporary enclosures that achieve the remedial action objectives identified in the OU 3-13 Record of Decision [DOE-ID 1999]) will be placed over the release sites CPP-28, CPP-31, and CPP-79 in the TFF.

From the 2003 Agreement to Resolve Dispute (INEEL 2003a), the work remaining in Phase I include lining ditches, installing culverts, lining the evaporation pond, and putting the system into operation. The Phase II work remaining includes construction of an infiltration barrier over soil release sites CPP-28, CPP-31, and CPP-79 inside the TFF fence in accordance with the Agreement to Resolve Dispute (INEEL 2003a).

3.2 National Environmental Policy Act

The implementation regulations for NEPA require development of a detailed environmental analysis for any proposed federal action that could significantly affect humans and the environment (40 CFR 1501–1508, 2002). On September 19, 1997, DOE issued a "Notice of Intent to Prepare a High-Level Waste and Facilities Disposition Environmental Impact Statement, Idaho Falls, ID" (62 FR 182, 1997). The EIS was issued in September 2002. Closure of the TFF will be completed pursuant to the decisions made on the basis of the *Idaho HLW and Facilities Disposition Final EIS* (DOE 2002). The EIS identifies the following primary decision-making goals:

- How to treat INTEC mixed HLW so that it can be transported out of Idaho to a storage facility or repository
- How to treat and where to dispose of other radioactive wastes that are associated with the HLW Program at INTEC
- How to manage treated INTEC wastes that are ready to be transported out of Idaho
- How to close HLW-related facilities at INTEC, including TFF storage tanks, bin sets, the NWCF, facilities that would be constructed under the waste processing alternatives and treatment options, and associated laboratories and support facilities.

3.3 Clean Water Act

The Clean Water Act (33 USC 1251 et seq., 1948), as implemented by IDAPA 58.01.02 (2002), prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the U.S. To ensure that no improper discharges from TFF closure or post-closure activities occur, the TFF storm-water management system will be integrated with the INTEC storm-water management system. As necessary, the INEEL storm-water pollution prevention documentation (DOE-ID 1998) will be revised to reflect any modifications required to manage runoff from the TFF during closure and post-closure activities.

3.4 Safe Drinking Water Act

The Safe Drinking Water Act requires that actions be taken to protect drinking water at its sources: rivers, lakes, reservoirs, springs, and groundwater. This act authorizes EPA to set national health-based standards for drinking water to protect against naturally-occurring and man-made contaminants that may be found in drinking water.

The EPA maximum contaminant levels (MCLs) for radionuclides are combined $^{226/228}$Ra of 5 pCi/L; a gross alpha standard for all alphas of 15 pCi/L, not including radon and uranium; a combined standard of 4 mrem/year for beta emitters. The new MCL for uranium is 30 µg/L. The revised radionuclide regulation requires new monitoring provisions requiring all water entering a distribution system to be tested to ensure that the water meets the MCLs for radionuclides in drinking water. These rules apply only to community water systems, which are water systems that have at least 15 service connections or serve 25 or more persons year-round.

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The Safe Drinking Water Act requires states to develop a source water assessment for use with all public water supplies in the state. This includes developing preventative protection measures for both surface and groundwater supplies. The assessment includes delineating the geographic area contributing water to public water supplies, conducting inventories of potential contaminant sources in that area, and determining the susceptibility of water supplies to those contaminant sources. The State of Idaho is in the process of developing this assessment, which is scheduled to be issued in May 2003. The PA considered the Safe Drinking Water Act MCLs in defining the performance objectives for the protection of groundwater. The MCLs are discussed in Section 4.1.2 of this document and in detail in the PA.

3.5 Resource Conservation and Recovery Act/Idaho Hazardous Waste Management Act

The closure of the TFF must meet the requirements of DOE Order 435.1 (DOE 2001a), RCRA (42 USC 6901 et seq., 1976), and HWMA (State of Idaho 1983). This Tier 1 Closure Plan provides the necessary information required by DOE Order 435.1. The tanks closures are required to meet the requirements of HWMA and RCRA, specifically IDAPA 58.01.009 (2002) and 40 CFR 265 (2002). IDAPA 58.01.009 incorporates 40 CRF 265 and all subparts (excluding Subpart R "Underground Injection," 40 CFR 265.149, "State Assumption of Responsibility," and 265.150, "Use of State-Required Mechanisms") by reference. The objective is to achieve clean closure of the tanks and tank system components in accordance with 40 CFR 265.110, 40 CFR 265.111, 40 CFR 265.112, and 40 CFR 265.197 (all 2002).

A RCRA/HWMA Closure Plan is being developed for each closure phase of the TFF that describes the closure activities necessary to achieve clean closure. Sampling after decontamination will be used to demonstrate that the tank residuals meet site-specific action levels for hazardous constituents along with the performance objectives of the PA. Decontamination and sampling to support the integration of DOE Order 435.1 and RCRA/HWMA are discussed in more detail in Section 2.5.2.

3.6 National Historic Preservation Act

The TFF is potentially eligible for listing in the National Register of Historic Places as contributing elements to the INEEL National Historic District. Activities associated with the TFF closure require consultation with the Idaho State Historic Preservation Officer in accordance with the National Historic Preservation Act (16 USC 470 et seq., 1966) and 36 CFR 800 (2002) (DOE-ID 1999b).

3.7 Clean Air Act

In compliance with the Federal Clean Air Act (42 USC 7401–7671g, 1955), the State of Idaho regulates emissions of criteria air pollutants, toxic air pollutants, and radionuclides through IDAPA 58.01.01 (2002). A determination regarding air permitting applicability will be prepared to assess the potential air and radionuclide emissions from the proposed TFF closure activities. The determination will likely identify that a permit to construct from the State of Idaho will be required, as modifications to the INTEC air system will be necessary.

The determination will also identify the requirements from the National Emission Standards for Hazardous Air Pollutants (NESHAP). The State of Idaho, through the NESHAP regulations of 40 CFR 61 (2002), regulates potential radionuclide emissions. To determine NESHAP compliance, modeling is conducted to estimate the dose to a maximally exposed individual (MEI) at that INEEL boundary. In accordance with NESHAP, if the modeled, unmitigated, potential emissions exceed 0.1 mrem/yr, monitoring would be required on a new or modified emission source. All radiological emissions to the environment, including those from all point and diffuse sources, must demonstrate compliance with the NESHAP

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standard and be submitted for reporting in the INEEL NESHAP annual report that is filed in accordance with 40 CFR 61 (2002) requirements.

3.8 Toxic Substances Control Act

Before closure, the tank residuals will be evaluated to determine whether or not polychlorinated biphenyl (PCB) compounds are present. In 1997, small quantities of PCB-contaminated material went through the PEW evaporator system and, therefore, possibly to the TFF (INEEL 2000b). Sample results and/or process knowledge will be used to determine if TSCA regulations for management and disposal of PCBs are applicable.

Before 1970, PCBs were routinely added to some paint as part of its original formula. Thus, the possibility exists that paint containing PCBs was applied to supporting structures and equipment (e.g., valve boxes). Items coated with paint potentially containing high levels of PCBs are considered PCB bulk product waste under the definition in TSCA regulation 40 CFR 761.3 (2002):

> *PCB bulk product waste means waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal was ≥50 ppm PCBs. . . . PCB bulk product waste includes, but is not limited to: (1) Non-liquid bulk wastes or debris from the demolition of buildings and other man-made structures manufactured, coated, or serviced with PCBs. . . .*

3.9 Additional Requirements

Additional requirements, which will be documented and implemented through lower-level project documentation, are listed below.

- 10 CFR 830.203 (2003), "Unreviewed Safety Questions," and 10 CFR 830.205 (2003), "Technical Safety Requirements"
- 10 CFR 835 (2003), "Occupational Radiation Protection," and DOE Order 5400.5 (DOE 1993), "Radioactive Protection of the Public and the Environment"
- 10 CFR 1021 (2003), "Compliance with the National Environmental Policy Act," and DOE Order 451.1B (DOE 2001c), "National Environmental Policy Act Compliance Program"
- 10 CFR 1022 (2003), "Compliance with Floodplains/Wetlands Environmental Review"
- DOE Order 430.1A (DOE 1998), "Life Cycle Asset Management," and DOE Guide 430.1-4 (DOE 1999c), "Decommissioning Implementation Guide"
- DOE Order 200.1 (DOE 1996a), "Information Management," and DOE Order 414.1-1A (DOE 2001d), "Quality Assurance"
- DOE Order 210.1 (1996b), "Performance Indicators and Analysis of Operations Information," 10 CFR 820 (2003), "Procedural Rules for DOE Nuclear Activities," and DOE Order 480.19 (DOE 2001e), "Conduct of Operations Requirements for DOE Facilities"
- DOE Policy 450.4 (DOE 1996c), "Safety Management System Policy," and DOE Guidance 450.4-1B (DOE 2001f), "Integrated Safety Management System Guide."

3.10 Facility Documents that May Impact Closure

Several documents were reviewed to determine if they would impact the design or implementation of the closure action. These include

- *Idaho Nuclear Technology and Engineering Center, Safety Analysis Report [SAR], Tank Farm Facilities SAR-107* (Hartwig 2001)

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- *Idaho National Engineering and Environmental Laboratory Site Treatment Plan* (INEEL 2001b)

- *The U.S. Department of Energy Idaho Operations Office and Bechtel BWXT, LLC Authorization Agreement for the INTEC Tank Farm Facilities* (INEEL 2002b)

- *Idaho HLW and Facilities Disposition Final Environmental Impact Statement* (DOE 2002)

- *Environmental Management Performance Management Plan for Accelerating Cleanup of the Idaho National Engineering and Environmental Laboratory* (DOE-ID 2002b)

- *Final Record of Decision, Idaho Nuclear Technology and Engineering Center* (DOE-ID 1999a)

- *Operable Unit 3-14 Tank Farm Soil and Groundwater Phase I Remedial Investigation/ Feasibility Study Work Plan* (DOE-ID 2000a).

3.10.1 Safety Analysis Report for TFF

The TFF SAR establishes the operating conditions for the TFF. The SAR discusses the risks of normal operations, abnormal operations, and postulated accidents to workers, the public, and the environment. The following sections are a summary of the results covered in detail in the TFF SAR (Hartwig 2001).

Nuclear facilities with hazardous chemical inventories at or above threshold quantities must follow the principles and requirements established in 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals" (2002).

The SAR includes radiation exposure to facility workers during normal TFF operations such as waste transfers, instrumentation monitoring and calibration, tank inspection and sampling, and maintenance. Radiation exposures are maintained as low as reasonably achievable (ALARA), and below radiation protection standards and DOE administrative limits, by adherence to the radiation protection program.

TFF design features and administrative controls ensure worker radiation protection. The location of the tanks and piping underground and the secondary containment for the tanks and waste transfer systems are the principal protective design features. Access control, work controls established by radiological work permits, and dosimetry provide administrative controls.

A qualitative hazard analysis of TFF operations was performed to identify and evaluate potential hazards caused by internal events, external events, and natural phenomena. Both occupational hazards, including common industrial hazards, and non-routine hazards were identified. Occupational hazards are controlled by compliance with DOE-prescribed occupational safety and health standards. Non-routine hazards identified result from the inventory of radioactive and hazardous material in the TFF.

Potential hazardous events that could result in the uncontrolled release of radioactive or hazardous material and affect the public, workers, or the environment were identified and evaluated to determine potential causes, estimated likelihood, consequences, risk, design features, and administrative controls that prevent occurrence or mitigate consequences. Potential hazardous events evaluated included radioactive and hazardous material releases from failed tanks, waste transfer piping, or components; fires and hydrogen deflagrations or detonations; natural phenomena (i.e., seismic and flooding); and several external events. Based on a criticality safety analysis of the fissile material contained in the TFF, an inadvertent criticality was determined to be beyond extremely unlikely (Hartwig 2001).

Based on the hazard analysis, the following three representative and bounding accidents were selected for further quantitative analysis:

- A hydrogen deflagration or detonation in a 300,000-gal storage tank

- A major storage tank failure, which bounds credible hazardous events that cause significant liquid releases to the vault

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- An airborne release from a valve box caused by a waste transfer system leak.

The results of the quantitative consequence analysis for these three postulated accidents show the risk to the public (i.e., a hypothetical MEI at the INEEL boundary) and collocated worker (i.e., within 300 ft [100 m] of the postulated accident) are well below the INEEL Risk Evaluation Guidelines (DOE 2000b) without consideration of preventative or mitigative measures. In addition, neither acute worker fatalities nor serious injuries to workers are expected from these postulated accidents (Hartwig 2001).

The TFF-specific technical safety requirements (TSRs) (INEL 2002b) derived from the hazard evaluation and accident analysis make up the waste compatibility control program. The following safety requirements were also identified:

- Acidic conditions for critical safety
- Operability requirements for the air purge system, including minimum air flow and periodic surveillance requirements
- Hydrogen monitoring controls for tank entry
- TFF load controls that prevent failure of the 300,000-gal tank vaults resulting from static and dynamic loads
- Waste transfer controls that prevent or mitigate, by early detection, waste transfer leaks or mistransfers
- Prohibition of liquid waste transfers to the 30,000-gal storage tanks (WM-103 through WM-106).

Based on the hazards evaluation, a number of environmental controls and requirements are identified based on the hazard analysis. These environmental volume limits (i.e., maximum of 285,000 gal [1.08E+06 L]), spare tank availability, tank liquid-level monitoring instrumentation, recovery action in the event of a tank leak, and radiation leak detection instrumentation for the waste transfer system.

The current SAR is not adequate to establish a safety basis for some activities performed during closure. These activities are being addressed in an amendment to the SAR.[a] The SAR will be revised before initiating any closure activities.

3.10.2 INEEL Site Treatment Plan

Under the Federal Facility Compliance Act of 1992 (42 USC 6961 et seq., 1992), DOE was required to enter into an agreement with the State of Idaho regarding how it would attain compliance with applicable treatment requirements for mixed wastes. The STP (INEEL 2001b) sets forth the terms and conditions to which DOE must comply to satisfy the land disposal restrictions applicable to the hazardous components in mixed wastes at INTEC. The plan proposes treating mixed HLW and mixed TRU/SBW by calcination through the NWCF and processing the waste into forms suitable for disposal at a remote-handling immobilization facility. In accordance with the provisions of the plan, the waste treatment proposals will be updated annually by DOE to be consistent with programmatic decisions.

3.10.3 The U.S. Department of Energy Idaho Operations Office and Bechtel BWXT, LLC Authorization Agreement for the INTEC Tank Farm Facilities

The *U.S. Department of Energy Idaho Operations Office and Bechtel BWXT, LLC Authorization Agreement for the INTEC Tank Farm Facilities* (INEEL 2002a) contains the key terms and conditions (controls and commitments) under which BBWI is authorized to perform work at the TTF. This agreement documents the basis for the safe conduct of work. Based on the INTEC Tank Farm SAR (SAR-107), the completion of the Final EIS for the INEEL Environmental Restoration and Waste Management Program, the performance of operational readiness review/readiness assessments, and the institutional

a. INEEL, 2003b, *Safety Analysis Report for the TFF Closure Project*, Draft, SAR-107A, expected release of May 2003.

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and support programs and processes, DOE has determined that BBWI has adequate technical and managerial capabilities to safely operate the TFF. This authorization specifically provides for the activities involved with

- Handling, monitoring, transferring, and storing radioactive and mixed hazardous liquid waste
- Handling and transport of Tank Farm samples
- Closure activities.

DOE-ID has determined that the Authorization Basis sufficiently covers the requirements needed for a radioactive waste management basis as required by DOE Order 435.1-1. The closure design and implementation is enveloped within this authorization.

3.10.4 Idaho HLW and Facilities Disposition Final Environmental Impact Statement

DOE has prepared the *Idaho HLW and Facilities Disposition Final Environmental Impact Statement* (DOE 2002) to inform agency officials and the public of the environmental impacts and alternatives available for consideration to a) treat and dispose of the mixed transuranic wastes and SBW, b) place the mixed HLW calcine in a form suitable for disposal in the national geologic repository, and c) dispose of HLW management facilities at INTEC. Based on the information presented in the final EIS and the public comments, DOE and the State of Idaho each selected their preferred alternatives.

The State of Idaho preferred alternative is the direct vitrification described in Section 3.1.6 of the EIS. This alternative includes the vitrification of mixed transuranic waste/SBW and vitrification of HLW calcine without or without separations.

The DOE preferred waste processing alternative is to select from among the action alternatives, options, and technologies analyzed in the EIS. Specifically, DOE's preferred alternative for waste processing is to

- Select appropriate technologies and construct facilities necessary to prepare SBW for shipment to the Waste Isolation Pilot Plant
- Prepare the mixed HLW calcine so that it will be suitable for disposal in a repository
- Treat and dispose of associated radioactive waste
- Provide safe interim storage of HLW destined for a repository.

Both DOE and the State of Idaho have designated a performance-based closure method as the preferred alternative for disposition of HLW facilities at INTEC. These methods encompass three of the six facility disposition alternatives analyzed in the EIS: clean closure, performance-based closure, and closure to landfill standards. These methods are consistent with the closure approach proposed for the TFF in this closure document.

3.10.5 Environmental Management Performance Management Plan for Accelerating Cleanup of the Idaho National Engineering and Environmental Laboratory

The *Environmental Management Performance Management Plan for Accelerating Cleanup of the Idaho National Engineering and Environmental Laboratory* (DOE-ID 2002b), describes DOE's approach to accelerate the reduction of environmental risk at the INEEL by completing its cleanup responsibility faster and more efficiently than previously planned. The plan describes an investment strategy for cleanup funding including the benefits of increased funding through the cleanup reform account. The plan is a product of DOE-ID and its contractors in consultation with the State of Idaho and EPA. The plan specifically mentions the acceleration closure of the TFF as one of its strategic initiatives. The TFF closure as defined in this Tier 1 document is fully aligned with the accelerated cleanup plan. A ROD is expected during 2003. This ROD is required before any irreversible closure actions are initiated.

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3.10.6 CERCLA—Final Record of Decision, Idaho Nuclear Technology and Engineering Center

The INTEC Waste Area Group (WAG) 3 is one of ten INEEL WAGS identified by the FFA/CO (IDHW, EPA, and DOE-ID 1991). Operable Unit (OU) 3-13 is listed as the WAG 3 Comprehensive RI/FS (Rodriguez et al. 1997).

The *Final Record of Decision, Idaho Nuclear Technology and Engineering Center* (DOE-ID 1999a) discusses the disposition of 101 identified release sites within the INTEC facility. Of the 101 sites, 55 were considered to present unacceptable risk or pose a threat; 40 sites were determined to require "no action" or "no further action." The remaining six sites were judged to be more appropriately managed under other OUs, WAGs, or INEEL regulatory programs. The Tank Farm soils fall into the category of being addressed under other OUs.

These TFF soil sites, combined into OU 3-14, consist of contaminated soils that resulted from spills and pipeline leaks of radioactive liquids from plant liquid transfer operations. Contamination resulting from releases from waste transfer lines and valve boxes in the Tank Farm area account for approximately 95% of the known contaminant inventory at INTEC (in curies of radioactive material). No evidence has been found to indicate that any of the Tank Farm tanks have leaked. Contaminants found in the interstitial soils are likely the result of accidental releases and leaks from process piping, valve boxes, or sumps, and cross-contamination from operation and maintenance excavations.

A final remedy for the Tank Farm soils is not addressed in the OU-13 ROD. The final remedy is deferred, pending further characterization and coordination with the *Idaho HLW and Facilities Disposition Final Environmental Impact Statement*. A separate proposed plan, and ROD will be prepared for the Tank Farm soils.

As noted in Section 3.1, the Tank Farm interim action was designed to restrict potential direct exposure from the soils within the TFF and minimize potential leaching and transport of contaminants to the perched water or SRPA (DOE-ID 2000b). These goals will be accomplished by completing all work outside the TFF fence and installation of an infiltration barrier over soil release sites CPP-28, CPP-31, and CPP-79 inside the TFF fence in accordance with the Agreement to Resolve Dispute (INEEL 2003a).

The implementation of the ROD should not affect the TFF closure design or implementation. The interim actions for OU 3-14 will not affect the TFF closure design but could have a minor impact on the logistics associated with implementing the closure. The Tier 2 closure document will address any impacts from the interim actions on implementing the closure.

3.10.7 Operable Unit 3-14 Tank Farm Soils and Groundwater Phase I Remedial Investigation and Feasibility Study Work Plan

The *Operable Unit 3-14 Tank Farm Soil and Groundwater Phase I Remedial Investigation/ Feasibility Study Work Plan* (DOE-ID 2000a) is a planning document for the remedial investigation, baseline risk assessment, and feasibility study for contaminated soils at the TFF. The current level of understanding of the OU-3-14 site is not adequate to make a risk-based management decision about the most appropriate remedies. The plan provides for the studies to determine the levels and extent of contamination and associated risks. Treatment options will be evaluated with the final RI/FS report, scheduled to be issued in 2008.

The work plan recognizes the ongoing closure activities at the TFF, noting that any final remedy consisting of capping, containment, in-situ treatment, or removal and ex-situ treatment of contaminated soil around the TFF cannot be implemented as a final remedy until the closure of the TFF has been implemented and decommissioning and decontamination has removed adjacent facilities. The plan assumes that the tanks, vaults, and associated piping within the TFF will be stabilized and that tanks will be included in OU 3-14 as they are closed to ensure a consistent final remedy for the TFF. As such, the

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CERCLA activities associated with OU 3-14 will not impact the TFF closure design or implementation.

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4. PERFORMANCE ASSESSMENT SUMMARY

The TFF PA (DOE-ID 2003a) was conducted to evaluate the radiological waste constituents at the TFF. The objectives, assumptions, inventory, pathways and scenarios, results, and uncertainty/sensitivity analysis are summarized in this section. The methods used to analyze the long-term performance are discussed in detail in the PA. The flowchart in Figure 4-1 illustrates the PA process. The analysis starts with a description of the radionuclide inventory and the development of the radionuclide source term, the TFF inventory, potential mechanisms of contaminant release from the TFF, and potential mechanisms responsible for loss of integrity of the engineered TFF barriers.

Following the source inventory discussion, receptors, significant pathways to human exposure, and exposure scenarios are discussed. The conceptual models developed and the computational approach used to assess the performance of the TFF are also summarized.

4.1 Identification of Performance Objectives

Applicable closure performance objectives were identified for the following: 1) protection of the public, 2) protection of water resources, 3) protection of intruders, and 4) ALARA.

4.1.1 Protection of the Public

DOE Manual 435.1-1 defines three performance objectives for protection of the public. The first performance objective, from DOE Manual 435.1-1, P. (1)(a), states:

> *Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air* (DOE 2001b).

This performance objective is interpreted as requiring the performance analysis to provide a reasonable expectation that the "all pathways" dose to a hypothetical future member of the public will not exceed 25 mrem. This objective includes all modes by which a receptor at the point of public access could be exposed, including the air pathway.

In accordance with the requirements of DOE Manual 435.1-1, P.(2), the PA covers a timeframe of 1,000 yr following closure of the TFF. Other analyses included in the sensitivity and uncertainty analysis go beyond 1,000 yr to calculate the maximum dose and the time of that dose as a means of increasing confidence in the modeling results. In addition, the point of compliance normally is located at the point of highest calculated dose beyond a 300-ft (100-m) buffer zone surrounding the waste.

The second performance objective from DOE Manual 435.1-1, P. (1)(b), states

> *Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny* (DOE 2001b).

This objective is consistent with NESHAP (40 CFR 61, 2002), in which ^{220}Rn, ^{222}Rn, and their progeny, need not be included in the air pathway analysis for comparison with the performance objective.

For the air pathway dose analysis, the point of compliance should be the point of highest calculated dose beyond a 300-ft (100-m) buffer zone surrounding the waste. The 10-mrem/yr limit refers to all sources, not just the post-closure TFF.

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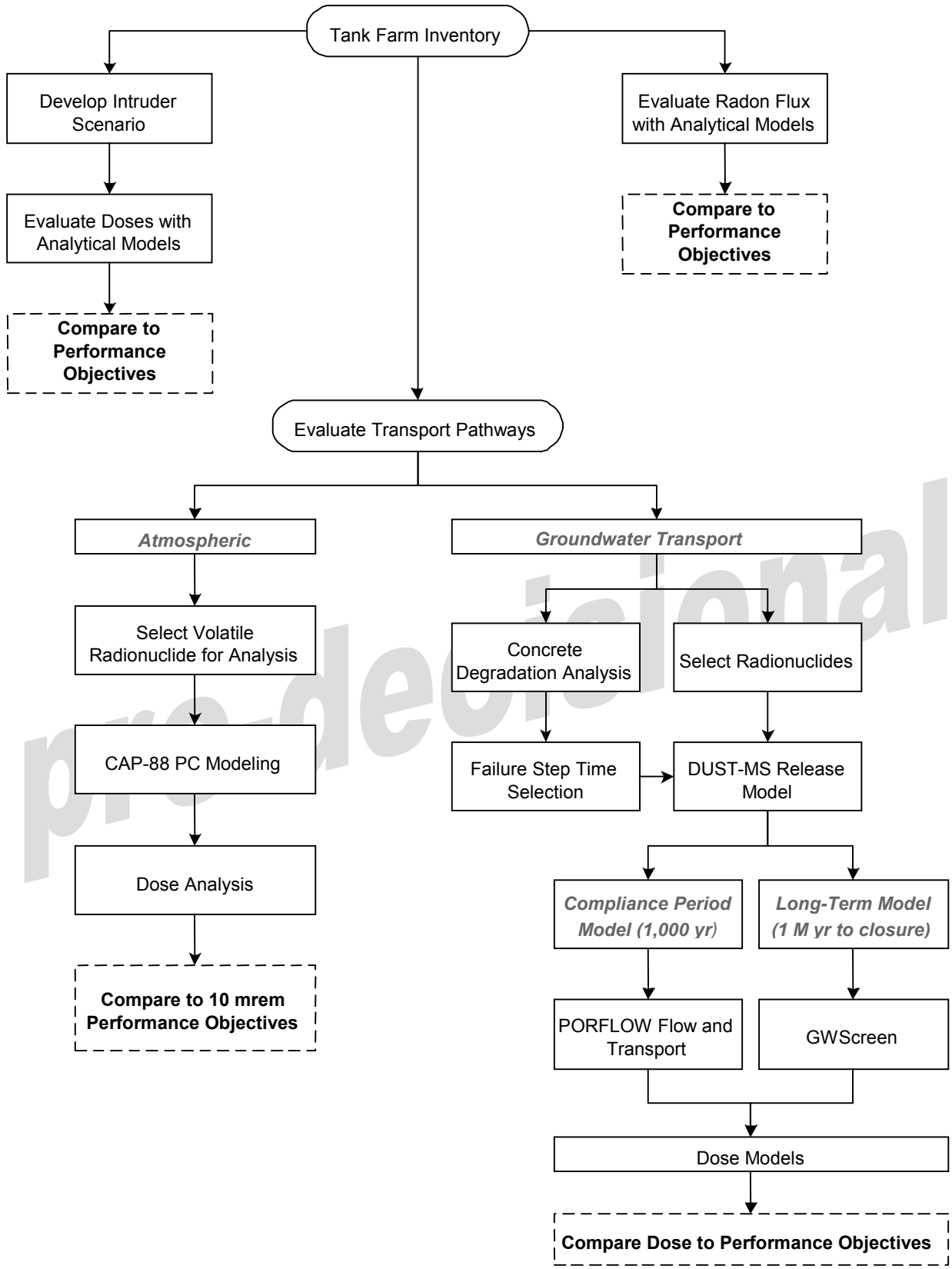

Figure 4-1. TFF PA process.

The third performance objective, from DOE Manual 435.1-1, P. (1)(c), states:

> *Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/L (0.0185 Bq/L) may be applied* (DOE 2001b).

A separate limit is applied for radon. In most cases, the limit is an average ground surface emanation rate of 20 pCi/m^2/s directly over the closure site.

4.1.2 Protection of Water Resources

The performance objective for groundwater protection of 4-mrem/yr effective dose equivalent (EDE) for all radionuclides is used in the PA. The selection of this site-specific performance objective is based on guidance from DOE Order 435.1. The order itself does not specify a radiation dose or concentration limit as a performance objective for groundwater. However, DOE Manual 435.1-1 requires an analysis of potentially applicable state and local requirements or agreements for groundwater protection. Six options for this objective were evaluated. A complete discussion of these options can be found in the PA (DOE-ID 2003a).

The use of a 4-mrem/yr EDE for all radionuclides as a performance objective is more restrictive than EPA's proposed revisions of the drinking water standards for radionuclides. While EPA's proposed standards also specify a dose limit of 4 mrem/yr, it applies only to beta- and gamma-emitting radionuclides. The concentration limits for alpha-emitting radionuclides would be added to this standard, effectively increasing the total limit to 5 mrem/yr. Use of the 4 mrem/yr for all radionuclides (including alpha) is more restrictive and, thus, more appropriate for a bounding analysis. The 4-mrem/yr limit also simplifies the assessment of the groundwater pathway, as the need to separate radionuclides in terms of dose or concentration is unnecessary.

4.1.3 Protection of Intruders

The inadvertent intruder scenario is evaluated in the PA; however, no specific performance objective is specified for this scenario (DOE-ID 2002a). However, DOE Manual 435.1-1, IV.P.(2)(h), does state:

> *For purposes of establishing limits on the concentration of radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the low-level waste disposal facility. For intruder analysis, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 yr following closure. The intruder analysis shall use performance measures for chronic and acute exposure scenarios, respectively, of 100 mrem (1 mSv) in a year and 500-mrem/year (5 mSv) total effective dose equivalent excluding radon in air* (DOE 2001b).

The 100-mrem/yr EDE was used in the PA to assess chronic exposure from residing at or frequently visiting the site. The 500-mrem/yr EDE was used to assess acute exposure from individual events that could reasonably occur at the site considering regional social customs and construction practices, such as excavation and well drilling.

Intrusion was assumed to occur no sooner than 100 yr following facility closure and was not analyzed beyond 1,000 yr after closure in accordance with the requirements of DOE Manual 435.1-1 (DOE 2001b). The onset of the intrusion scenario may be extended beyond 100 yr if adequate justification is provided (i.e., continued DOE presence for facility decommissioning). Passive controls, such as marker systems and engineered features, may be effective in deterring

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accidental intrusion onto the closure site and may be used as justification for extending the onset of intrusion (DOE-ID 2003a).

4.1.4 ALARA Principle

DOE has implemented the ALARA principle to radiation protection in all of its operations, including closure. DOE Manual 435.1-1, P. (2)(f), states:

> *Performance assessments shall include a demonstration that projected releases of radionuclides to the environment shall be maintained as low as reasonably achievable*
> (DOE 2001b).

The ALARA principle requires that projected doses be maintained to levels that are lower than the specified standards if "reasonably achievable." The goal of the ALARA process is attainment of the lowest practical dose level after taking into account social, technical, and public policy considerations (DOE 2001b).

4.2 PA Assumptions

Preparation of the PA source term involved several key assumptions:

- A key element of the PA and CA is the radiological source inventory, which is an estimate of the radionuclides and their calculated activities remaining after TFF closure. The source inventory is based on the measured activity of ^{137}Cs in Tank WM-188 as a bounding value. Tank WM-188 had the highest radionuclide concentrations of the three tanks with recent sample data (WM-182, WM-183, and WM-188). Historically, ^{137}C has been used in conjunction with ORIGEN2 to characterized waste for treatment in the NWCF. As such, the source inventory is the bounding inventory that will not be exceeded during the closure phases.

- For the intruder scenario, it is assumed that active institutional control will be maintained at the TFF for at least 100 yr after closure.

- The acute intruder scenario assumes that an inadvertent intruder drills a well into the contents of a tank and vault system and is exposed to both the contaminated drill cuttings spread over the ground and contaminated airborne dust.

- The chronic intruder scenario assumes that an inadvertent intruder moves onto the TFF and drills a residential well in the waste. The drill cuttings are spread over an area of approximately 0.5 acre (0.2 ha). The intruder is assumed to ingest contaminated food products from the garden and from beef and dairy cattle that consumed contaminated forage.

4.3 Radionuclide Source Inventory

4.3.1 Source Inventory

The bounding tank radionuclide source inventory estimate (Table 4-1) is based on the most recent analytical sampling results from direct grab samples of heels in Tanks WM-182, WM-183, and WM-188; historical data regarding the contents of the eleven 300,000-gal tanks; and the ORIGEN2[a] numerical code (Croff 1980). The source inventory is designed to be conservative based on the assumed tank contents of liquid and solids while being realistic by using current sampling data. The conservative approach was maintained by using the highest radionuclide concentrations in Tank WM-188 as explained below.

The heels in Tanks WM-182, WM-183, and WM-188 were recently sampled to determine the presence and quantity of radioactive and hazardous constituents. Historically, samples were collected from operating tanks by pumping primarily liquid waste to holding tanks in the NWCF, but these samples were collected for operational data and were not intended for use in characterizing the solid and liquid in the tanks for

a. Isotope Generation and Depletion Code Matrix Exponential Method.

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Table 4-1. Radionuclide source inventory used in the PA.

Nuclide	Liquid Activity (Ci)	Solid Activity (Ci)	Total Activity (Ci)	Nuclide	Liquid Activity (Ci)	Solid Activity (Ci)	Total Activity (Ci)
^{225}Ac	5.7E–09	3.4E–08	4.0E–08	^{152}Eu	2.0E–02	1.2E–01	1.4E–01
^{227}Ac	8.6E–07	5.2E–06	6.0E–06	^{154}Eu	9.1E–01	3.0E–01	1.2E+00
^{228}Ac	1.0E–11	6.2E–11	7.2E–11	^{155}Eu	1.1E–01	2.4E+00	2.6E+00
^{108m}Ag	6.3E–09	3.8E–08	4.4E–08	^{221}Fr	5.7E–09	3.4E–08	4.0E–08
^{241}Am	1.8E–01	4.4E–01	6.2E–01	^{223}Fr	1.2E–08	7.2E–08	8.4E–08
^{242}Am	2.2E–04	1.3E–03	1.6E–03	^{152}Gd	2.2E–14	1.3E–13	1.6E–13
^{242m}Am	2.2E–04	1.3E–03	1.6E–03	^{3}H	8.0E–02	4.8E–01	5.6E–01
^{243}Am	3.2E–04	1.9E–03	2.2E–03	^{166m}Ho	6.9E–07	4.1E–06	4.8E–06
^{217}At	5.7E–09	3.4E–08	4.0E–08	^{129}I	3.7E–04	2.2E–03	2.6E–03
^{137m}Ba	5.7E+02	3.4E+03	4.0E+03	^{115}In	1.5E–12	8.9E–12	1.0E–11
^{10}Be	4.6E–08	2.8E–07	3.2E–07	^{138}La	3.0E–12	1.8E–11	2.1E–11
^{210}Bi	8.6E–08	5.2E–07	6.0E–07	^{93m}Nb	2.9E–02	1.7E–01	2.0E–01
^{210m}Bi	3.3E–21	2.0E–20	2.3E–20	^{94}Nb	1.7E–02	7.7E+00	7.7E+00
^{211}Bi	8.6E–07	5.2E–06	6.0E–06	^{144}Nd	2.5E–11	1.5E–10	1.7E–10
^{212}Bi	2.9E–05	1.7E–04	2.0E–04	^{59}Ni	1.3E–02	1.6E–01	1.7E–01
^{213}Bi	5.7E–09	3.4E–08	4.0E–08	^{63}Ni	4.3E–01	2.6E+00	3.0E+00
^{214}Bi	2.0E–07	1.2E–06	1.4E–06	^{237}Np	1.7E–03	5.9E–03	7.6E–03
^{14}C	4.9E–01	1.1E–05	4.9E–01	^{238}Np	1.1E–06	6.5E–06	7.6E–06
^{113m}Cd	2.7E–02	1.7E–01	1.9E–01	^{239}Np	3.2E–04	1.9E–03	2.2E–03
^{142}Ce	4.6E–07	2.8E–06	3.2E–06	^{240m}Np	1.0E–11	6.2E–11	7.2E–11
^{144}Ce	9.1E–08	5.5E–07	6.4E–07	^{231}Pa	1.5E–06	8.9E–06	1.0E–05
^{249}Cf	2.6E–13	1.5E–12	1.8E–12	^{233}Pa	4.5E–02	2.7E–01	3.1E–01
^{250}Cf	1.1E–13	6.5E–13	7.6E–13	^{234}Pa	4.1E–07	2.4E–06	2.8E–06
^{251}Cf	4.1E–15	2.4E–14	2.8E–14	^{234m}Pa	3.2E–04	1.9E–03	2.2E–03
^{242}Cm	1.8E–04	1.1E–03	1.3E–03	^{209}Pb	5.7E–09	3.4E–08	4.0E–08
^{243}Cm	3.2E–04	1.9E–03	2.2E–03	^{210}Pb	8.6E–08	5.2E–07	6.0E–07
^{244}Cm	1.6E–02	9.6E–02	1.1E–01	^{211}Pb	8.6E–07	5.2E–06	6.0E–06
^{245}Cm	4.6E–06	2.8E–05	3.2E–05	^{212}Pb	3.0E–05	1.8E–04	2.1E–04
^{246}Cm	3.0E–07	1.8E–06	2.1E–06	^{214}Pb	2.0E–07	1.2E–06	1.4E–06
^{247}Cm	3.3E–13	2.0E–12	2.3E–12	^{107}Pd	2.5E–04	1.5E–03	1.7E–03
^{248}Cm	3.6E–13	2.2E-12	2.5E–12	^{146}Pm	1.5E–04	8.9E–04	1.0E–03
^{60}Co	7.0E–02	1.4E–01	2.1E–01	^{147}Pm	8.6E–02	5.2E–01	6.0E–01
^{134}Cs	6.0E–03	4.7E–02	5.3E–02	^{210}Po	8.6E–08	5.2E–07	6.0E–07
^{135}Cs	1.4E–02	8.3E–02	9.6E–02	^{211}Po	0.0E+00	0.0E+00	0.0E+00
^{137}Cs	5.7E+02	3.4E+03	4.0E+03	^{212}Po	1.8E–05	1.1E–04	1.3E–04
^{150}Eu	1.7E–07	1.0E–06	1.2E–06	^{213}Po	5.7E–09	3.4E–08	4.0E–08

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Table 4-1. (continued).

Nuclide	Liquid Activity (Ci)	Solid Activity (Ci)	Total Activity (Ci)	Nuclide	Liquid Activity (Ci)	Solid Activity (Ci)	Total Activity (Ci)
^{214}Po	2.0E–07	1.2E–06	1.4E–06	^{90}Sr	4.1E+02	7.6E+03	8.0E+03
^{215}Po	8.6E–07	5.2E–06	6.0E–06	^{98}Tc	3.9E–08	2.4E–07	2.8E–07
^{216}Po	3.0E–05	1.8E–04	2.1E–04	^{99}Tc	1.5E–01	9.0E–01	1.0E+00
^{218}Po	2.0E–07	1.2E–06	1.4E–06	^{123}Te	5.7E–15	3.4E–14	4.0E–14
^{144}Pr	9.1E–08	5.5E–07	6.4E–07	^{125m}Te	1.9E–03	1.1E–02	1.3E–02
^{144m}Pr	1.1E–09	6.5E–09	7.6E–09	^{227}Th	8.6E–07	5.2E–06	6.0E–06
^{236}Pu	1.7E–06	1.0E–05	1.2E–05	^{228}Th	3.0E–05	1.8E–04	2.1E–04
^{238}Pu	2.8E+00	1.4E+01	1.7E+01	^{229}Th	5.7E–09	3.4E–08	4.0E–08
^{239}Pu	3.5E–01	9.0E–01	1.2E+00	^{230}Th	1.4E–05	8.3E–05	9.6E–05
^{240}Pu	1.6E–01	9.6E–01	1.1E+00	^{231}Th	3.2E–04	1.9E–03	2.2E–03
^{241}Pu	2.1E+00	1.3E+01	1.5E+01	^{232}Th	1.1E–11	6.5E–11	7.6E–11
^{242}Pu	1.2E–04	7.2E–04	8.4E–04	^{234}Th	3.2E–04	1.9E–03	2.2E–03
^{244}Pu	1.0E–11	6.2E–11	7.2E–11	^{207}Tl	8.6E–07	5.2E–06	6.0E–06
^{223}Ra	8.6E–07	5.2E–06	6.0E–06	^{208}Tl	1.0E–05	6.2E–05	7.2E–05
^{224}Ra	3.0E–05	1.8E–04	2.1E–04	^{209}Tl	1.3E–10	7.6E–10	8.8E–10
^{225}Ra	5.7E–09	3.4E–08	4.0E–08	^{171}Tm	6.9E–14	4.1E–13	4.8E–13
^{226}Ra	2.0E–07	1.2E–06	1.4E–06	^{232}U	2.9E–05	1.7E–04	2.0E–04
^{228}Ra	1.0E–11	6.2E–11	7.2E–11	^{233}U	3.7E–06	2.2E–05	2.6E–05
^{87}Rb	4.5E–07	2.7E–06	3.1E–06	^{234}U	1.3E–02	7.6E–02	8.8E–02
^{102}Rh	5.7E–07	3.4E–06	4.0E–06	^{235}U	6.0E–05	4.1E–04	4.7E–04
^{106}Rh	1.8E–06	1.1E–05	1.3E–05	^{236}U	3.2E–05	3.1E–03	3.1E–03
^{219}Rn	8.6E–07	5.2E–06	6.0E–06	^{237}U	5.3E–05	3.2E–04	3.7E–04
^{220}Rn	3.0E–05	1.8E–04	2.1E–04	^{238}U	8.2E–05	2.4E–04	3.3E–04
^{222}Rn	2.0E–07	1.2E–06	1.4E–06	^{240}U	1.0E–11	6.2E–11	7.2E–11
^{106}Ru	1.8E–06	1.1E–05	1.3E–05	^{90}Y	4.1E+02	7.6E+03	8.0E+03
^{125}Sb	7.4E–03	4.5E–02	5.2E–02	^{93}Zr	3.3E–02	2.0E–01	2.3E–01
^{126}Sb	8.6E–04	5.2E–03	6.0E–03				
^{126m}Sb	6.3E–03	3.8E–02	4.4E–02				
^{79}Se	6.9E–03	4.1E–02	4.8E–02				
^{146}Sm	4.2E–09	2.5E–08	3.0E–08				
^{147}Sm	1.1E–07	6.9E–07	8.0E–07				
^{148}Sm	5.7E–13	3.4E–12	4.0E–12				
^{149}Sm	5.2E–14	3.1E–13	3.6E–13				
^{151}Sm	4.7E+00	2.8E+01	3.3E+01				
^{121m}Sn	7.3E-4	4.5E–03	5.2E–03				
^{126}Sn	6.3E–03	3.8E–02	4.4E–02				

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closure. In contrast, the recent sampling events were designed to collect solid and liquid data directly from the tanks to determine an initial characterization of the waste stream and provide defensible data of tank solids and liquids.

Data from Tanks WM-182, WM-183, and WM-188 were examined to determine which tank contained the highest radionuclide concentrations; Tank WM-188 contained the highest concentrations. ^{137}Cs was used as an indicator for residual radionuclide concentrations in the tanks because, historically, ^{137}Cs was used during the operations period of the NWCF to predict concentrations of other nuclides that could not be detected as easily or efficiently. The ^{137}Cs data and ORIGEN2 numerical code for prediction of nuclide concentration in nuclear fuel (or in this case, nuclear fuel waste streams during and after reprocessing) has successfully been used in the past by INTEC Operations to predict concentrations of various nuclides in waste streams headed for calcination.

The inventory was established initially based on ORIGEN2 data and then adjusted proportionally with respect to the predicted and measured ^{137}Cs concentration in Tank WM-188. The mean concentration of ^{137}Cs in Tank WM-188 was used in the calculations to adjust the source term generated by ORIGEN2. Radionuclides that were detected in WM-188 were input directly into the inventory and the ORIGEN2 values were removed. Many nuclides are not detected in the TFF waste stream because of the relatively high concentrations of radioactivity in the waste. The sample matrix makes it difficult to detect radionuclides with low energy emissions or with relatively low concentrations. The utility of using ORIGEN2 data is increased because it provides a starting point from which to calculate a concentration. Total strontium is used for ^{90}Sr because of the short half-lives of other strontium isotopes.

Details of the tank inventory are contained in Section 2.3.1 of the PA. Based on ORIGEN2 data and analytical sampling results, the bounding tank source inventory in 2016 will be 24,102 Ci. The year 2016 is used because it was the final closure date during the development of the PA. Efforts are now underway to complete closure by 2012. Modeling in the PA and CA is based on this source inventory. Activity in the solids portion accounts for 92% (22,133 Ci) of the total curies. Only a small number of the total nuclides provide significant activity in the source term: ^{238}Pu and ^{241}Pu in the transuranic radionuclides and ^{90}Sr, ^{90}Y, ^{137}Cs, and ^{137}Ba in the non-transuranic radionuclides.

A comparison of the estimated ^{137}Cs inventory in the 30,000-gal tanks (0.046 Ci) with the ^{137}Cs content of the 300,000-gal tanks (4.0E+04 Ci) indicates that the levels in the 30,000-gal tanks are insignificant by comparison. Therefore, the inventory for the 300,000-gal tanks is considered to "bound" any additional contamination that may be released from the 30,000-gal tanks. The estimate was based on data from samples collected in 1990 before the tanks were emptied.

4.3.2 Degradation Analysis

The following discussion provides an overview of the degradation analysis of the TFF closure system. The conservative assumptions used in the PA degredation analysis were chosen to ensure that the PA is a bounding analysis of the TFF closure.

Potential degradation mechanisms for the concrete, grout, piping, tanks, and the preferential water pathways were assessed. For modeling purposes, the following four zones were defined:

- The outer concrete vault walls, roof, and floor
- The grout inside the vault, but outside the tank
- The tank and the grout inside the tank
- The piping.

Conceptually, because these zones contain potential water pathways arising from initial conditions, each zone has a non-zero initial permeability (Seitz and Walton 1993). Over time, various mechanisms that increase permeability cause tanks to corrode and concrete and grout to degrade. The degradation mechanisms and processes considered in this analysis that can

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affect the system's permeability include initial conditions (cracks and voids), sulfate and magnesium attack, calcium hydroxide leaching, alkali-aggregate reaction, carbonation, acid attack, and corrosion of the tank, pipes, and reinforcements.

The degradation analysis results for the concrete vaults predict that the grout and tanks will degrade to rubble after 5,000 yr and the pipes will completely corrode in approximately 40,000 yr. Additionally, the model for localized corrosion used in the degradation analysis predicted that the first hole in the tank, which is assumed to occur at the same rate as in the pipes, appears at approximately 10,000 yr. Because the PA is concerned with releases in the first 1,000 yr, the only releases predicted from the pipes would occur from initial leaks. To be conservative, the PA assumed degradation of the vaults occurred in 100 yr and the degradation of the tanks and piping in 500 yr. The degradation analysis for the piping is presented in detail in the PA (DOE-ID 2003a).

4.4 Identification of Pathways and Scenarios

The following subsections describe the time periods of concern and possible contaminate transport and exposure pathways of TFF constituents potentially released after closure. This information was used in the PA (DOE-ID 2003a) to conduct modeling and determine potential dose(s) from the closed TFF.

4.4.1 Time Periods of Concern

Two time periods of concern, the institutional control period and the post-institutional control period, are identified to assess the performance of the TFF closure.

4.4.1.1 Institutional Control Period. The institutional control period is a 100-yr time interval following closure of the TFF, as specified in DOE Manual 435.1-1 (DOE 2001b). Although work is underway to accelerate tank closure, for purposes of this analysis, a closure date of 2016 was used. Therefore, the institutional control period is assumed to last until 2116. During this period, the TFF is assumed to be fenced and still physically and administratively part of the INEEL; stabilized; no longer operational; and routinely inspected to minimize the possibility of inadvertent intruders. Periodic maintenance and monitoring activities would be conducted during the institutional control period.

4.4.1.2 Post-Institutional Control Period. The post-institutional control period is assumed to start after the institutional control period and will continue until 1,000 yr from the time of closure (3016). It is assumed that the facility is no longer physically or administratively controlled by the INEEL. Projection of conditions and activities during this time period are uncertain and difficult to assess. Complicating matters, peak doses may not occur from TFF releases until several thousand years after closure because of the presence of long-lived radionuclides. Regardless, for compliance purposes, the performance period is 1,000 yr after facility closure during which reasonable human activities are assumed to occur, based upon the existing population patterns for the INEEL region. To address the potential peak doses from the long-lived radionuclides after this time period, sensitivity analyses were performed.

4.4.2 Transport Pathways

Radionuclides released from the TFF have the potential of reaching humans through numerous pathways. The most conceivable pathways for a buried LLW source are indicated in Figure 4-2. The pathways identified in this figure are for undisturbed facilities (from the standpoint of human intrusion). Each pathway is defined in the legend of Figure 4-2.

4.4.2.1 Pathway Screening. Because Figure 4-2 is generic in nature, the significance of each pathway must be evaluated on a site-specific basis to develop an exposure model. Many pathways may be removed from consideration because of their negligible contribution to human exposure.

For the TFF, leaching and transport of radionuclides to the saturated zone [pathway (1)] is the predominant means that radionuclides may be subsequently transported in the environment.

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Thus, this pathway must be addressed in developing an exposure model and was addressed in the PA in the groundwater model. Other pathways that may contribute to human exposure are those tied to groundwater concentrations of contaminants. Irrigation with contaminated groundwater may lead to contamination of agricultural crops and animals [pathways (3), (21), (23), (25) and (26)]. Ingestion of contaminated groundwater by terrestrial animals [pathway (19)] may lead to human exposure and can be tied to groundwater contamination. Human exposure may occur as a result of direct human ingestion of contaminated groundwater [pathway (41)] and as a result of consumption of contaminated food supplies [pathways (44) and (45)]. These pathways were all considered for the PA exposure scenarios.

Discharge of contaminated groundwater to surface water [pathway (6)] may result in contamination of the aquatic ecosystem including the water body itself, sediment, and aquatic plants and animals [pathways (13), (14), (15), (34), (35), (36), (37), (38), and (39)]. The groundwater at the INEEL does not intersect the Big Lost River in the vicinity of the INEEL; however, it does interact with surface water as springs that flow into the Snake River. Major areas of springs and seepages from the aquifer occur in the vicinity of the American Falls Reservoir (southwest of Pocatello), approximately 44 mi (71 km) from the TFF, and the Thousand Springs area (near Twin Falls) between Milner Dam and King Hill, approximately 100 mi (200 km) away (Garabedian 1986). These spring locations are at such great distances from the TFF that any contribution to the human dose from surface water at these locations would be insignificant because of groundwater dilution. Therefore, these pathways are not considered further in the PA. In addition, exposure pathways associated with the ingestion of surface water, swimming, aquatic animals, or associated plant and animal uptake of radionuclides from surface water [pathways (16), (17), (18), (33), (40), and (46)] also were not considered for further analysis.

Pathway (7) considers contamination of groundwater from recharge by surface-water. This pathway is not considered significant for the TFF, because the migration of radionuclides to the nearby surface water body (i.e., Big Lost River) is not considered possible.[b] Pathways (8) and (20), representing contamination of cover soil and terrestrial plants as a result of irrigation with contaminated surface water, also are not considered. These pathways were withdrawn because of a lack of a physical mechanism to move the radionuclides from the source to the surface water. Contamination of surface water from erosion of contaminated soil [pathway (9)] was not considered significant because movement of the contaminants from their present location below the ground surface to the surface is not considered feasible (i.e., no erosion of 10-ft [3-m] cover soil). In addition, pathways (22) and (27), representing the pathways to surface soil via decomposition of terrestrial plants and animals, were not considered significant relative to the exposure resulting from direct consumption of these potentially-contaminated products.

Pathways that result in human exposure directly or indirectly as a result of atmospheric dispersion and deposition [pathways (4), (5), (10), (11), (24), (28), (29), (30), (31), (32), and (47)] are not included in exposure scenarios for the PA for the following reasons:

- The only potentially volatile radioactive components of the TFF are ^{3}H and ^{14}C. Calculations providing an upper bound on doses received from volatilization of these radionuclides from the TFF after closure are described in the PA.

- The pathway leading to exposure from resuspended contaminated soil [pathway (11)] is not considered because no mechanism for releasing particulates from the TFF is available.[b]

Other atmospheric pathways are indirect in nature (e.g., the contaminants must first be suspended, or volatilized, from one medium

b. The waste at this time is in a grouted form buried beneath the ground surface such that the interaction of the waste with surface water is not physically possible.

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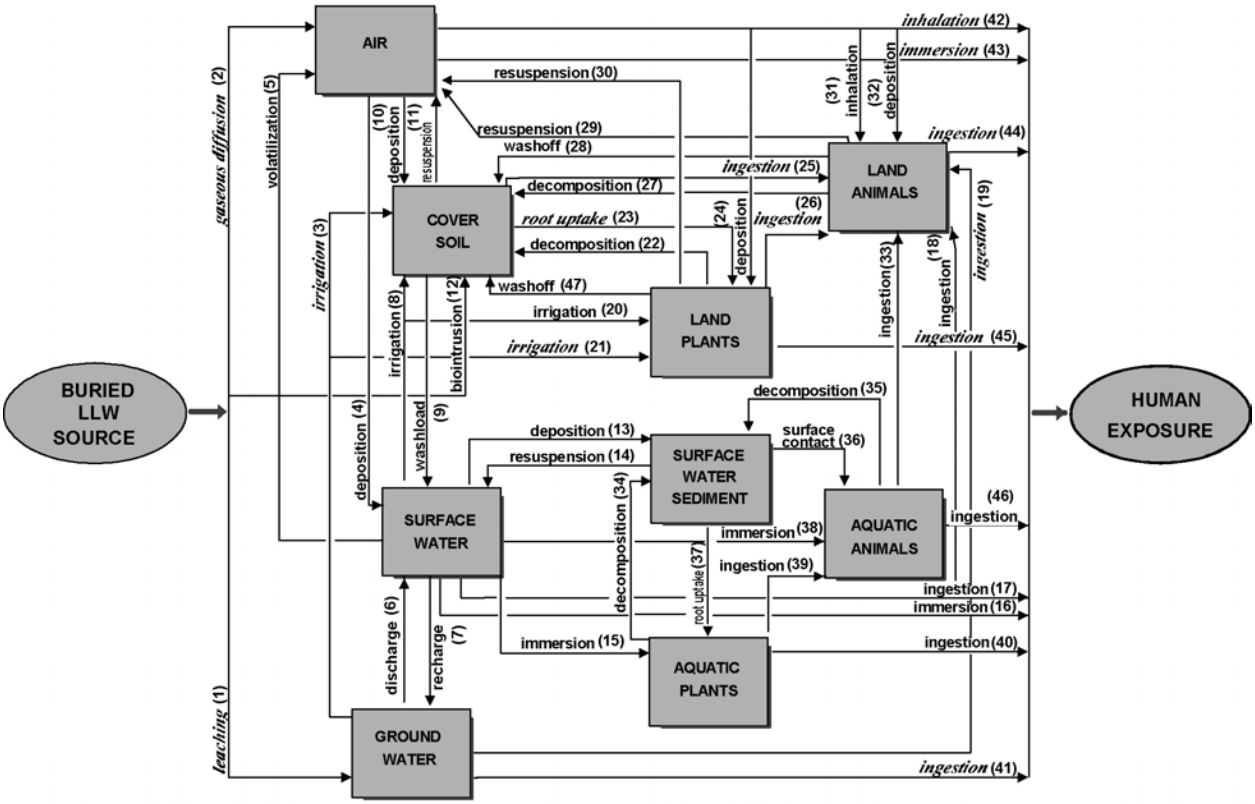

Figure 4-2. Potential transport and exposure pathways from a near-surface facility (pathways selected for analysis [see legend - next page] are identified by italics).

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(1) *Leaching*—migration of radionuclides from the waste form by a combination of dissolution, diffusion, and advection.

(2) *Gaseous Diffusion*—upward migration of gaseous radionuclides from the waste form by diffusion through the caps and cover soils to the atmosphere.

(3) *Irrigation*—contamination of cover soil by radionuclides that have reached groundwater, which is subsequently used for irrigation.

(4) Deposition—contamination of surface water by radionuclides that have reached the atmosphere; represents deposition of particulate-associated radionuclides or gaseous species partitioning at the air-water interface.

(5) Volatilization—partitioning of volatile radionuclides species present in surface water into air above the water body.

(6) Discharge—discharge of radionuclides present in groundwater into surface water.

(7) Recharge—movement of radionuclides into the groundwater from contaminated surface water.

(8) Irrigation—contamination of cover soil by radionuclides that have reached surface water, which is subsequently being used for irrigation.

(9) Washload—contamination of surface water by soil containing radionuclides as a result of erosion by rain or irrigation water.

(10) Deposition—contamination of cover soil by radionuclides that have reached the atmosphere and have become associated with airborne particulate matter.

(11) Resuspension—Resuspension of soil-associated radionuclides as a result of wind erosion.

(12) Biointrusion—contamination of cover soil by soil-associated radionuclides that are brought to the surface from the vicinity of the waste form by burrowing animals, such as rodents or ants, or by intruding plant roots.

(13) Deposition—deposition of radionuclides in surface water that have partitioned onto suspended sediment.

(14) Resuspension—resuspension of particulate-borne radionuclides in the sediment of surface water as a result of hydrodynamic forces at the sediment-water interface.

(15) Immersion—contamination of aquatic plants by radionuclides in surface water attributable to the immersion of the plants in the contaminated water.

(16) Immersion—human exposure to radionuclides as a result of immersion in contaminated surface water.

(17) Ingestion—human exposure to radionuclides as a result of ingestion and inhalation of radionuclides present in surface water.

(18) Ingestion—contamination of terrestrial animals from their ingestion of radionuclides in surface water.

(19) *Ingestion*—contamination of terrestrial animals from their ingestion of radionuclides in groundwater.

(20) Irrigation—contamination of terrestrial plants as a result of irrigation with surface water containing radionuclides.

(21) *Irrigation*—contamination of terrestrial plants as a result of irrigation with groundwater.

(22) Decomposition—contamination of cover soil as a result of decomposition of terrestrial plants in the soil.

(23) *Root uptake*—contamination of terrestrial plants by uptake through roots of soil water containing radionuclides.

(24) Deposition—deposition of airborne radionuclides onto terrestrial plant surfaces.

(25) *Ingestion*—ingestion of radionuclides by grazing animals as a result of contaminated soil ingestion.

(26) *Ingestion*—ingestion of radionuclide-containing vegetation by terrestrial animals.

(27) Decomposition—contamination of cover soil as a result of decomposition of terrestrial animals in the soil.

(28) Washoff—contamination of surface soil as a result of washoff of externally-contaminated terrestrial animals.

(29) Resuspension—resuspension of surficial radionuclides on terrestrial animals to the atmosphere.

(30) Resuspension—resuspension of surficial radionuclides on terrestrial plants to the atmosphere.

(31) Inhalation—contamination of terrestrial animals as a result of inhalation of radionuclides in the atmosphere.

(32) Deposition—surface contamination of terrestrial animals via deposition of particulate-borne radionuclides in the atmosphere.

(33) Ingestion—contamination of terrestrial animals as a result of their ingestion of aquatic animals.

(34) Decomposition—contamination of surface water sediment as a result of decomposition of aquatic plants in the sediment.

(35) Decomposition—contamination of surface water sediment as a result of decomposition of aquatic animals in the sediment.

(36) Surface contact—surface contamination of aquatic animals as a result of contact with contaminated sediment.

(37) Root uptake—contamination of aquatic plants via radionuclide uptake through roots.

(38) Immersion—contamination of aquatic animals as a result of immersion in surface water containing radionuclides.

(39) Ingestion—contamination of aquatic animals as a result of their ingestion of aquatic plants containing radionuclides.

(40) Ingestion—human exposure to radionuclides as a result of ingestion of contaminated aquatic flora.

(41) *Ingestion*—human exposure to radionuclides as a result of ingestion of contaminated groundwater.

(42) *Inhalation*—human exposure to radionuclides as a result of inhalation of airborne radionuclides.

(43) *Immersion*—human exposure to radionuclides as a result of immersion in contaminated air.

(44) *Ingestion*—human exposure to radionuclides as a result of ingestion of contaminated terrestrial animals and animal products (such as milk).

(45) *Ingestion*—human exposure to radionuclides as a result of ingestion of contaminated terrestrial plants.

(46) Ingestion—human exposure to radionuclides as a result of ingestion of contaminated aquatic animals.

(47) Washoff—contamination of surface soil below vegetation due to rain-induced surface washoff.

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and then redeposited in another). These indirect pathways are not believed to be more significant than the direct pathways (2), (42), and (43) and, thus, are not addressed in the PA.

Therefore, pathways (2), (42), and (43) are included in the dose analysis for atmospheric releases of ^{3}H, and ^{14}C.[c]

Finally, it is acknowledged that biointrusion is a potentially significant pathway of contamination of cover soil over a LLW facility (McKenzie et al. 1983). However, studies at the INEEL have indicated that burrowing animals and plant roots for species of the area do not exceed 7 ft (2 m) in depth. Therefore, given the 10 ft (3 m) of cover over the vaults, pathway (12) is not considered in the PA.

In summary, of the original 47 pathways identified in Figure 4-2, the following were considered to be of possible consequence to off-site members of the public and are considered further in the PA:

- Pathways related to contaminated groundwater believed to be of potential consequence, including leaching of the waste form that results in direct contamination of groundwater and indirect contamination of agricultural crops and animals as a result of subsequent irrigation with the contaminated groundwater [pathways (1), (3), (19), (21), (23), (25), (26), (41), (44), and (45)].

- The release of the volatile radionuclides ^{3}H and ^{14}C [pathways (2), (42), and (43)].

4.4.3 Exposure Scenarios

Five exposure scenarios were selected and modeled in the PA. The models included those for the 1) drinking water dose from groundwater 2) all-pathways, 3) air pathway, 4) radon flux, and 5) intruder pathway.

c. The requirements for radon are specified as a flux term in the performance objectives and are dealt with separately.

The drinking water dose and all-pathways dose exposure scenarios were developed to provide the mechanism for evaluating the performance criteria in terms of groundwater protection and the all-pathways dose objective.

4.4.3.1 Drinking Water Scenario. As discussed in Section 4.1.2, the groundwater protection standard is a drinking water dose of 4 mrem/yr. The primary mechanism for transport of radionuclides from the TFF is expected to be leaching of radionuclides to the groundwater and subsequent human consumption. Thus, in the dose analysis for groundwater protection, an off-site member of the public is assumed to use water from a well for domestic purposes. The well is assumed to be located at a minimum of 100 m (300 ft)[d] from the TFF, where the maximum concentrations of radionuclides in groundwater are predicted to occur.

During the period of institutional control, off-site members of the public are assumed to be located no closer to the closure site than the present boundary of the INEEL. However, after active institutional control ceases, off-site members of the public could be located as close as 100 m (300 ft) from the TFF.

4.4.3.2 All Pathways Exposure Scenario. The primary mechanism for transport of radionuclides from the TFF is assumed to be leaching of radionuclides to the groundwater and subsequent human consumption. In the all-pathways dose analysis, an off-site member of the public is assumed to use water from a well for domestic purposes. The well is assumed to be located a minimum of 100 m (300 ft) from the TFF, where the maximum concentrations of radionuclides in groundwater are predicted to occur.

d. Data input to the modeling software must be in metric units. Therefore, throughout these sections, measurements that are inputs are given in metric units, followed by U.S. customary units.

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The following exposure pathways involving the use of contaminated well water are assumed to occur:

- Direct ingestion of contaminated water
- Ingestion of milk and meat from dairy and beef cattle that drink contaminated water
- Ingestion of vegetables grown in soil irrigated with contaminated water
- Ingestion of milk and meat from dairy and beef cattle that eat fodder from pasture irrigated with contaminated water.

Additional exposure pathways for off-site members of the public could involve release of radionuclides into the air (i.e., volatile radionuclides) and, thus, are also considered in the all-pathways dose.

4.4.3.3 Air Dispersion Scenario. Volatile radionuclides ^{3}H and ^{14}C were evaluated in the air dispersion scenario. The depth to the waste and the waste physical characteristics (i.e., grouted waste) limits the analysis to volatile radionuclides in the waste form. Additional details on the air dispersion scenario are provided in the PA (DOE-ID 2003a).

4.4.3.4 Radon Flux. The PA considers the flux of radon from a grouted slab of residual waste (DOE-ID 2003a). The slab is assumed to be on the surface in open air. No credit was taken for the tank, vault, or soil covering the tanks, making the approach very conservative.

4.4.3.5 Intruder Pathway. The hypothetical intruder was assumed to inadvertently intrude onto the TFF during the post-institutional control period. Four intruder scenarios were evaluated in the PA (DOE-ID 2003a). The first was an acute scenario, which consisted of exposure while developing a water well. In the well-drilling scenario, the receptor was exposed to contaminated drill cuttings spread over the ground. The second scenario involved an acute scenario where the intruder was assumed to excavate a basement. The third scenario was chronic exposure in an agricultural scenario based on drill cuttings from the development of the water well. The well cuttings were assumed to be spread over the ground, and the intruder then began farming activities. The fourth scenario was also a chronic exposure, which consisted of an agricultural scenario based on the excavation of contaminated soil to develop a basement.

4.5 Models

4.5.1 Source Term Model

The source term modeling of release rates from the vaults and tanks was conducted with the Disposal Unit Source Term-Multiple Species (DUST-MS) (Sullivan 1993, 1996) computer code. A brief description of the conceptual approach to model the release rates from the vaults and tanks and the DUST-MS model input parameters are presented below. A detailed discussion is presented in the PA (DOE-ID 2001b).

DUST-MS considers four major processes: fluid flow, container degradation, waste form leaching, and contaminant transport. The DUST-MS model permits selection of a unique failure time and waste form type for each container. To simulate different waste forms, DUST-MS has four different models to estimate release rates: rinse with partitioning, diffusion, uniform degradation, and solubility-limited release. For these four models, DUST-MS computes release rates with an analytical model or a finite difference model. After calculating waste form releases, the movement of the contaminants through subsurface system materials is determined using a one-dimensional finite difference procedure with material- and contaminant-specific distribution coefficients, diffusion coefficients, dispersion coefficients, and bulk densities. The governing transport equation simulates the distribution and movement of contaminants resulting from advection, dispersion, diffusion, radioactive production and decay, sorption, and sources and sinks external to the containers. The DUST-MS code has received extensive testing and verification. DUST-MS code predictions compare favorably to known analytical solutions as well as other code predictions.

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The conceptual model for computing release rates of radionuclides out of the TFF vault is illustrated in Figure 4-3. Infiltrating water from the ground surface contacts the waste inside the vaults. The release of radionuclides from the sand pad and liquid and solid waste remaining in the grouted tank heel was modeled in DUST-MS and assumed surface rinsing. The vault was assumed to remain intact for 100 yr and the stainless-steel tanks were assumed to remain intact for 500 yr. Upon vault and tank failure, radionuclides were released from the three sources.

The DUST-MS code calculated release rates out of the vault and tanks into the unsaturated zone. Radionuclides in the liquid and solid waste remaining in the grouted tank heel were modeled separately in DUST-MS. Release rates were computed for transport through the grout inside the tank (0.15 m [5.9 in.]), the sand pad (0.15 m [5.9 in.]), and the degraded concrete (0.76 m [30. in.]). Retardation was assumed to occur in the waste release model (surface rinsing), in the grout inside the tank, in the sand pad, and in the degraded concrete. For consistency with DOE calculations, different partition coefficients in the grouted tank heel were used to determine releases from the liquid waste and solid waste in the tank grout. In this analysis, advection is assumed to dominate transport and diffusion is not modeled.

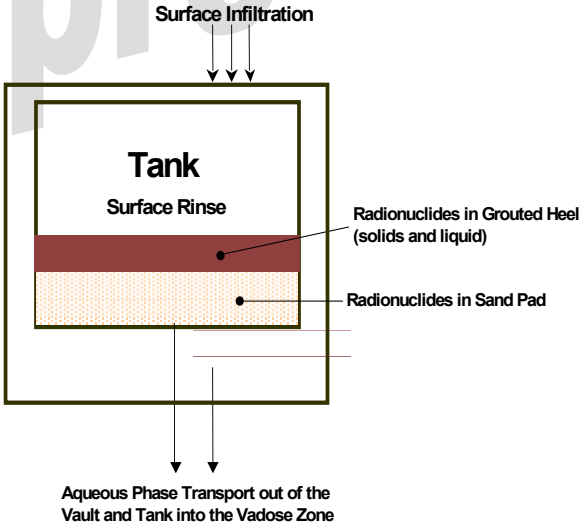

Figure 4-3. DUST-MS conceptual model for release from the TFF vaults and tanks.

The releases determined using the DUST-MS model were input into the PORFLOW groundwater model.

4.5.2 Groundwater Flow and Transport Model

PORFLOW (ACRi 2000) is a comprehensive mathematical model for the simulation of multiphase fluid flow, heat transfer, and mass transport processes in variably saturated porous and fractured media. The code can be used to simulate transient or steady-state problems in Cartesian or cylindrical geometry. The geologic medium may be anisotropic and heterogeneous and may contain distinct embedded elements such as discrete fractures or boreholes within a porous matrix. In partially saturated zones, liquids and gases are assumed to coexist. The degree of saturation of each phase is determined at each grid node as part of the solution. The dependent variable, or its change from the current state, approximates the flux terms. Several options are provided for the incorporation of sources or sinks of fluid, heat, or mass. Fluid injection or withdrawal, sources or sinks of heat, or chemical species may occur anywhere in the interior of the domain of interests. For chemical species, the sources can be limited by their inventory, solubility, or both.

PORFLOW numerically solves a variable set of equations for general transport, multiphase pressure, temperature, and one or more chemical species. The method of nodal point integration is employed for integration of the governing differential equations by temporal and spatial discretization over each control volume (element) of the physical domain. The method also leads to solutions that automatically conserve fluid, heat, and mass locally within every grid element, as well as for the entire flow domain.

The PORFLOW code is particularly well suited for simulating the transport of fluid and contaminants from the TFF waste forms through the underlying unsaturated zone and into the regional aquifer. Unlike previous simulations (conducted for the Radioactive Waste Management Complex [RWMC] and INTEC sites) that relied on two or more codes,

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PORFLOW can be used to simulate both the release of contaminants from the waste form and the subsequent transport through the underlying geological media. Using a single simulation code eliminates the potential problems of transferring data output from one code to data input for the subsequent code. PORFLOW was designed especially for problems of fluid and mass transport in geologic media.

Several features of PORFLOW were especially important for the modeling simulations for the INTEC area. First, data existed for the waste inventory and solubility of the contaminants that would need to be used for the PA. This information was input to PORFLOW to estimate the contaminant source emanating from the TFF waste forms. These source terms were automatically input into the underlying unsaturated zone, transported to the aquifer based on hydraulic and retardation characteristics of the unsaturated zone, and then transported to the aquifer. Second, PORFLOW simulates transport under partial and complete saturation. Geologic media underlying the facility consists of fractured basalts and unconsolidated porous media. PORFLOW incorporated the planar geologic features such as fractures or faults with different length scales and properties to distinguish these features from the parent geologic media. This feature was useful for simulating flow in the fractured basalt instead of assuming a representative hydraulic conductivity for the entire basalt matrix. Finally, PORFLOW calculates contaminant flux values at any location in the problem domain. This feature allowed assessment of contaminant flux from the waste forms, the amount of contaminants held in the unsaturated zones, and the flux of contaminants entering the regional aquifer.

PORLFOW has a history of use specific in PAs. The code was successfully used for the Z-Area, Saltstone Facility, PA (Westinghouse Savannah River Company 1992) and the RWMC PA at the INEEL (Maheras et al. 1994). In summary, PORFLOW is a robust simulation code with direct application to the multiphase contaminant transport problem at INTEC. The code has been extensively validated by independent researchers and it has been used to model similar hydrogeologic systems at other DOE facilities.

4.5.2.1 Assumptions for the Perched Groundwater. The mechanisms surrounding the hydrologic and hydraulic factors that control the perched water zones underlying INTEC are not well understood and remain controversial. The sources of water causing the perched zones and the subsurface units responsible for restricting the downward movement of infiltrating water also are not fully understood. Further, it is not known if perched water zones existed before site activity began. Finally, there is disagreement on the subsurface units responsible for restricting the downward movement of infiltrating water. The literature states that fine-grain interbeds form the base of the perched water zones, while conversely, the interbeds and highly fractured basalts adjacent to the interbed zones commonly are the highest permeable regions in basalt flows. Cecil et al. (1991) state that lithologic features contributing to the contrasts in the vertical hydraulic conductivity of basalt layers and sedimentary interbeds in the unsaturated zone provide the mechanisms for the development of perched groundwater zones. Perched water at the Test Reactor Area (TRA), INTEC, and RWMC can be attributed to at least four lithologic features. First, the vertical hydraulic conductivity of a sedimentary interbed might be smaller than that of an overlying basalt flow. Second, alterations in the zone between two flows can contribute to reduced vertical hydraulic conductivity. Third, dense, unfractured basalt may inhibit unsaturated groundwater movement and contribute to the formation of perched groundwater zones. Fourth, sedimentary and chemical filling of fractures near the upper contact of a basalt flow reduces the vertical hydraulic conductivity. Selecting which of these mechanisms is responsible for the observed perched zones is an important assumption in the model simulation.

An important component of the conceptual model for the transport of contaminants is the relationship of dispersion in the two-dimensional model.

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Since the model uses a unit thickness of 1 m (3 ft), there is no lateral dispersion of contaminants beyond this thickness. It is assumed that contaminants disperse or diffuse out of the lateral boundary at the same rate as contaminants move into the unit thickness of the model domain. Essentially, all dispersion of contaminants occurs in the longitudinal direction, with zero transverse dispersion. This is a conservative approach to predicting downgradient contaminant concentrations.

Because the model domain is located in the center of the tanks, the highest contaminant concentrations are located in the source area of the model. Although it is assumed that the same amount of contaminants disperses in a transverse direction out of as into the model domain, in reality there would be the same loss of contaminants, albeit small, in the transverse direction. Consequently, downgradient contaminant concentrations will be slightly higher for the two-dimensional simulation compared to a fully three-dimensional simulation.

Radionuclide concentrations were observed downgradient in the regional aquifer at the location where the highest concentrations occur. During unsaturated flow simulations, it was observed that the perched water zones deflected the contamination. Consequently, the usual 100 m (300 ft) downgradient location was inappropriate to quantify the maximum impacts of radionuclide releases from the tanks and vaults. Based on the radionuclide concentrations distribution, the maximum observed concentrations occur approximately 600 m (2,000 ft) downgradient from the tanks.

The assumptions involving the perched water zones were the most important ones in developing and interpreting the numerical model. These assumptions affected the amount of water input into the system as well as the hydraulic characteristics of the underling formation.

For the initial phase of the model, it was assumed that no perched water zones result solely from infiltrating precipitation. Initially, the best-estimated subsurface stratigraphy, hydraulic parameters, and volume of infiltrating water were coded into the model. Subsurface stratigraphy and the volume of infiltration water remained constant during the model simulations. For subsequent simulations, which involved seepage losses from the Big Lost River and the percolation ponds, it was assumed that the development of perched water zones resulted from variations in the vertical hydraulic conductivity of selected subsurface units. Consequently, the development of perched water zones and the thickness and aerial extent of perched water were determined by comparing the model results with the existing hydrologic information and adjusting the vertical permeability of the appropriate subsurface unit to match model predictions with actual conditions.

4.5.3 Radon Transport Model

The PA evaluated radon flux from a grouted slab of residual waste, with finite thickness in one spatial direction and infinite thickness in the other two spatial directions (i.e., a one-dimensional model), which was submersed in air without radon. This model was conservative for the TFF site for several reasons:

- No credit for the tank or vault is assumed. These materials provide a significant barrier for radon transport to the surface of the facility.

- Submersion of the slab in radon-free air allows for the greatest possible diffusive flux out of the slab.

The conservative model was chosen to simplify the calculation for the greatest possible diffusive flux out of the slab.

4.5.4 Air Pathway (Volatile Radionuclide Model)

The release of gaseous species of ^{3}H and ^{14}C to the air above the TFF facility was assumed to be controlled by gaseous diffusion in the air-filled pore space.

The waste form was assumed to have a porosity and water content equal to the values associated with the alluvium (for conservatism) to estimate the volume of water in the waste. The

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inventory was assumed to be diluted within this volume.

The CAP88-PC computer model (EPA 1992) was used to determine the potential doses from the atmospheric pathway. The receptor was located 100 m (300ft) from the TFF. The analysis used 1992 wind data from the INEEL Grid-3 meteorological station (obtained from the National Oceanic and Atmospheric Administration Office at the INEEL).

4.5.5 The All-Pathways Dose Assessment

The process used to calculate the all-pathways dose is based on the methodology presented by the NRC in 10 CFR 61 (2003) and by the work of Peterson (1983) and Maheras et al. (1997). This all-pathways scenario assumes that a receptor receives radiation doses from consuming

- Contaminated groundwater
- Contaminated animal products (i.e., milk and beef from cattle that consume contaminated water and pasture grass irrigated with contaminated groundwater)
- Contaminated leafy vegetables and produce.

Radionuclide concentrations as a function of time at the receptor well were used as input to these dose models. The receptor was located at the INEEL boundary during the operational and institutional control periods; during the post-institutional control period, the receptor was located 100 m (300 ft) south (i.e., downgradient) of the TFF boundary for the air pathway and 600m (2000ft south for the groundwater pathway. The PA provides a complete list of parameters used in the all-pathways dose analysis (including distribution types and ranges) and the sources of information used to establish these ranges.

Secondary and indirect pathways such as inhalation of contaminated irrigation water and inhalation of contaminated dust were omitted from the model. The total human dose compared to the standards is the total dose received from all of the pathways.

4.6 Performance Assessment Results

The PA assessed risk to two populations, the general public and the inadvertent intruder. It was assumed that a hypothetical member of the public resides at the INEEL site boundary during the operational and institutional control periods. (The institutional control period is the first 100 yr after closure). During the post-institutional control period, the hypothetical member of the public was assumed to reside at INTEC. The risk to the general public was assessed through the analysis of several reasonable, yet conservative, scenarios that reflect site-specific conditions at the TFF. The risk to an inadvertent intruder was also assessed through the analysis of four conservative scenarios. The hypothetical inadvertent intruder was assumed to unintentionally intrude on the TFF after the institutional control period (100 yr). Four scenarios were evaluated; acute drilling, acute construction, chronic drilling and chronic construction. Tables 4-2 and 4-3 provide a summary of the PA results compared to the performance objective; all results were found to be less than their corresponding objective. The major contributors to the dose are ^{129}I, ^{99}Tc, ^{90}Sr, ^{14}C, and ^{137}Cs. The intruder sensitivities and uncertainties associated with these results are discussed in detail in Section 5.7 of the PA.

4.6.1 All-Pathways Dose

The results of the all-pathways assessment indicate that there is reasonable confidence that realized doses to a receptor will not exceed 25 mrem/yr for 1,000 yr after TFF closure. The all-pathways dose calculations were based on the groundwater pathways. The 95% confidence level was used as the metric for comparison to the standards to provide reasonable expectation that the performance objective was met.

The realized doses to a hypothetical receptor of 1.35 mrem/yr at 890 yr for the groundwater scenario and the atmospheric pathway dose of 0.51 mrem/yr for a total of 1.86 mrem/yr does not exceed the performance objective of 25 mrem/yr for 1,000 yr after project completion. The long-

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Table 4-2. Results of the pathways evaluated in the performance assessment.

Performance Objective	Performance Assessment Result
All-Pathways 25 mrem/yr	1.86 mrem/yr
Airborne Emissions Excluding Radon 10 mrem/yr	0.51 mrem/yr
Average Annual Radon Flux 20 pCi/m^2/s	0.39 pCi/m^2/s
Protection of Groundwater 4 mrem/yr	0.77 mrem/yr
Acute Drilling Scenario 500 mrem	232 mrem
Acute Construction Scenario 500 mrem	0.80 mrem
Chronic Post-drilling Scenario 100 mrem/yr	91.1 mrem/yr
Chronic Post-construction Scenario 100 mrem/yr	26.1 mrem/yr

Table 4-3. Performance assessment intruder results.

	Performance Assessment Result			
Performance Objective	100 yr	200 yr	500 yr	1,000 yr
Acute Drilling Scenario 500 mrem	232 mrem	46.5 mrem	18.8 mrem	16.3 mrem
Acute Construction Scenario 500 mrem	0.80 mrem	0.13 mrem	0.05 mrem	0.05 mrem
Chronic Post-drilling Scenario 100 mrem/yr	91.1 mrem/yr	10.9 mrem/yr	2.3 mrem/yr	2.2 mrem/yr
Chronic Post-construction Scenario 100 mrem/yr	26.1 mrem/yr	3.1 mrem/yr	0.64 mrem/yr	0.61 mrem/yr

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term analysis (one million year post-closure) indicates that peak doses do not exceed the performance objective.

4.6.2 Air Pathway Dose

The annual dose from volatile releases predicted by CAPP88-PC atmospheric transport runs resulted in a dose for ^{3}H releases of 0.008 mrem/yr and ^{14}C doses of 0.5 mrem/yr. The total dose of 0.5 mrem/yr is well below the atmospheric pathways performance objective of 10 mrem/yr and indicates that the atmospheric pathway will not contribute significantly to the all-pathways dose. This was a very conservative analysis because flux rates were based on simplified models and the receptor was located 100 m (300 ft) from the facility at all times. In

reality, the receptor would not be located near the TFF for the first 100 yr after closure because the site is assumed to be physically and administratively controlled.

4.6.3 Radon Flux Results

For ^{222}Rn (the dominant isotope in terms of atomic fraction), the flux of radon at the surface of the slab was 0.39 pCi/m^2/s. This is more than one order of magnitude below the performance objective (20 pCi/m^2/s). Given the conservative nature of the calculation, there are two reasons that this value is so low. First, cementitious materials do not transport radon very well, and second, the radium content of the grouted heel is relatively low. Although the bare slab model could not be shown to meet the standard for the shorter-lived isotopes of radon (^{220}Rn, half-life of 55.6 s, and ^{219}Rn, half-life of 3.96 s) the 0.5 m (2 ft) of overburden is capable of reducing these radon fluxes significantly. Therefore, the shorter-lived isotopes are quite incapable of penetrating even a modest overburden. Because of their shorter half-lives, they do not survive long enough to traverse the barrier.

4.6.4 Drinking Water Scenerio (Groundwater Protection)

The fundamental approach used in the numerical simulation of the unsaturated zone relied upon the United States Geological Survey (USGS) definition of the site hydrostratigraphy, precipitation estimates, and Big Lost River and percolation ponds seepage values. The hydraulic conductivity of low-permeable interbed was varied within reasonable ranges based on lithologic descriptions to predict the location and extent of the numerous perched water bodies underlying the INTEC facility.

A two-dimensional groundwater flow and transport model was used to simulate contaminant releases from the tanks. The model domain dissected the center of two tanks and one sand pad, and included the releases from a break in the piping, providing the maximum release of contaminants to the underlying soil and groundwater. The dose limit calculation was applied to the two-dimensional slice through the center of the tanks. In addition, the two-dimensional discretization of the problem domain allowed a high degree of resolution of the hydrostratigraphy, including the discontinuous interbeds that form the perched zones underlying the facility. By assuming that the USGS cross sections were accurate, the resulting numerical model predicted contaminant transport around the perched zones and through breaks in the interbeds. Dilution by perched water was minimized, and the point where the maximum contaminant concentrations entered the regional aquifer was identified and selected as the compliance point.

According to the results presented in the PA (Section 4), an individual who has a well at the point of the highest concentration receives a dose of 0.77 mrem/yr at 890 yr for the drinking water scenario (groundwater). The radionuclides contributing the highest dose are ^{129}I, ^{99}Tc, ^{90}Sr, and ^{14}C. This does not exceed the performance objective of 4 mrem/yr for 1,000 yr after project completion. The long-term analysis also indicates that peak doses do not exceed the performance objective during the period of closure to one million years post-closure.

4.6.5 Intruder Analysis Results

The maximum dose after institutional control (i.e., 100 yr) for the acute intruder drilling scenario was 232 mrem. The major radionuclide contributors to the total acute intruder scenario dose were ^{137}Cs/^{137m}Ba with 188 mrem, ^{238}Pu with 15 mrem, ^{90}Sr/^{90}Y with 8.64 mrem, ^{239}Pu with 5.3 mrem, ^{241}Am with 5.1 mrem, and ^{240}Pu with 2.8 mrem. The acute scenario dose results do not exceed the performance objective of 500 mrem for all times past institutional control.

The maximum dose post-institutional control (i.e., 100 yr) for the acute intruder-construction scenario was 0.80 mrem. The major radionuclide contributors to the total acute intruder dose were ^{137}Cs/^{137m}Ba with 0.72 mrem, ^{94}Nb with 0.045 mrem, ^{90}Sr/^{90}Y with 0.017 mrem, and ^{238}Pu with 0.013 mrem. The acute intruder-construction scenario dose results are less than the performance objective of 500 mrem for all times post-closure.

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The maximum dose after loss of the concrete vault integrity was 91.1 mrem/yr for the chronic intruder post-drilling scenario at 100 yr post-closure. The major radionuclide contributors to the total chronic intruder dose were $^{90}Sr/^{90}Y$ with 51.5 mrem/yr and $^{137}Cs/^{137m}Ba$ with 36.5 mrem/yr. The chronic intruder post-drilling scenario dose results do not exceed the performance objective of 100 mrem/yr during the compliance period.

The maximum dose was 26.1 mrem/yr for the chronic intruder post-construction scenario at 100 yr post-closure. The major radionuclide contributors to the total chronic intruder dose were $^{90}Sr/^{90}Y$ with 15.2 mrem/yr, $^{137}Cs/^{137m}Ba$ with 10.1 mrem/yr, ^{94}Nb with 0.58 mrem/yr, and ^{238}Pu with 0.15 mrem/yr. The chronic intruder post-construction scenario dose results do not exceed the performance objective of 100 mrem/yr for the 1,000-yr compliance period.

It is difficult to predict the future actions of humans, especially over a period of 1,000 yr. The fact that the intruder is assumed to drill a well directly through a tank is considered a very conservative assumption. It can be argued that the person drilling the well would not (or could not) continue to drill through the concrete and stainless-steel tanks and grout unless it was completely degraded. The analysis is very sensitive to the time of intrusion because the short-lived fission products are the main contributor to the intruder doses at 100 yr after closure as shown in Table 4-3.

4.6.6 ALARA Analysis

The PA includes ALARA assessments that focus on alternatives for LLW disposal or, in this case, closure of the TFF tanks. The rigor of the ALARA assessment, and its analysis of alternatives, needs to be commensurate with the magnitude of the risk and the decisions to be made. Depending on the situation, ALARA assessments can range from simple qualitative statements to elaborate quantitative assessments that consider individual and collective doses to members of the public.

To conduct an ALARA analysis, estimates of costs to conduct activities that reduce dose are needed. At this stage in the planned closure of the TFF, several of the costs to conduct specific activities beyond those already proposed have not been determined. Therefore, the PA for the TFF presents a qualitative ALARA analysis.

The doses calculated in the PA were based on a bounding inventory developed from process knowledge, conservative assumptions, and limited sampling. At the present time, the reduction in radionuclide inventories attributed to closure activities is unknown. However, as shown in the PA, the ^{129}I tank inventories, based on conservative calculations, resulted in a tank inventory of 0.01 Ci, while sample data after initial cleaning of Tank WM-182 indicate a tank inventory of 0.0004 Ci (DOE-ID 2003a).

The final doses predicted from TFF closure will likely be much less than those presented in the PA. However, until additional tank cleaning and sampling data are obtained, the cost and benefit of such reductions cannot be predicted with adequate certainty.

The PA evaluated the performance of the TFF based upon the exiting 10 ft (3 m) of soil cover. CERCLA actions will likely alter the existing infiltration environment and thus result in lower doses than predicted in the PA. The TFF soils are contaminated and are being evaluated under the INEEL CERCLA program. Alternatives for these contaminated soils include the construction of an engineered cover over the TFF and infiltration diversions.

4.7 Uncertainty and Sensitivity Analysis

To ensure that the sensitivities and uncertainties of the groundwater pathway modeling were thoroughly understood, a sensitivity/uncertainty analysis was conducted. A total of four scenarios were considered for the groundwater pathway analyses. These scenarios were termed (1) worst case, (2) conservative case, (3) realistic case, and (4) best case. The conservative case was used in the PA analyses to demonstrate compliance with the performance objectives. The worst-case scenario was used to

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evaluate the potential worst-case doses from the use of the worst-case parameter values, including the inventories and transport characteristics. The realistic scenario presents the analyses in relation to the expected behavior of the groundwater transport and the contaminant inventories expected to remain after cleaning of the tanks and piping. The best scenario uses the same transport parameter values as the realistic case; however, the inventory was further reduced to the level expected from the best available analysis of the cleaning technology. Such an evaluation was intended to demonstrate that the conservative case was, in fact, conservative and appropriate to use as the compliance case. Table 4-4 lists the results of the sensitivity/uncertainty analysis for the four groundwater pathway scenarios.

This sensitivity/uncertainty analysis indicates that the performance objectives for the groundwater pathway are met for three cases (i.e., conservative, realistic, and best). However, the worst-case scenario doses are above the performance objectives. To assess the degree of uncertainty in the groundwater doses, the four groundwater scenarios were run for the matrix of possibilities: (1) inventory), (2) infiltration rate, and (3) transport parameters (i.e., distribution coefficients). This matrix resulted in 36 groundwater scenario combinations.

The matrix analysis of parameter combinations resulted in a worst-case scenario considered to be a realistic "upper bound" of the dose analysis. This combination was the worst-case transport parameters, a conservative inventory, and a conservative infiltration rate. The conservative inventory is considered to be the upper bound of the final closure inventory based on preliminary data obtained from cleaning Tank WM-182. The cleaning process has been effective and the final inventories are expected to be less than those predicted in the conservative inventory calculations. The infiltration rate of 4.1 cm/yr is also considered to be the upper bound of the infiltration rate at the TFF. The TFF currently has a soil cover; the 4.1 cm/yr infiltration rate is based on measurements at the INEEL Central Facilities Area soil-covered landfill. Again, the infiltration rate will likely be reduced because an engineered cover is proposed for the TFF. However, the PA analyses do not take credit for this reduction for the compliance case. The realistic and best cases do include a reduction in the infiltration rat. The largest uncertainty in the analyses was considered to be the distribution coefficients for the TFF grout and the unsaturated zone.

The combination of the worst-case distribution coefficients, conservative inventory, and conservative infiltration rate resulted in a realistic, "upper bound," worst-case dose of 3.4 mrem/yr for the drinking water pathway (i.e., groundwater protection) and a dose of 15 mrem/yr for the all-pathways dose. These doses are less than the performance objectives. In summary, the worst-case groundwater doses were found to exceed the performance objectives; however, a combination of parameters in the matrix analysis presents a realistic, "upper bound" dose estimate for the worst-case that shows compliance with the performance objectives.

Uncertainty in the atmospheric pathway, radon flux, and intruder analyses doses were also investigated based on the four inventories for the TFF (i.e., worst-case, conservative, realistic, and best). Table 4-5 summarizes the results of the uncertainty analysis.

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Table 4-4. Groundwater pathway sensitivity/uncertainty results.

Groundwater Scenario	Drinking Water Dose (mrem/yr)	All-pathway Dose (mrem/yr)
Worst Case	23.1	85.8
Conservative Case	0.77	1.35
Realistic Case	0.04	0.07
Best Case	0.03	0.04

Table 4-5. Uncertainty analysis results.

Scenario and Performance Objective	Worst-case Inventory	Conservative Inventory	Realistic Inventory	Best Inventory
Acute Drilling Intruder (500 mrem)	276	232	193	144
Chronic Drilling Intruder (100 Mrem/yr)	106	91.1	75.1	52.8
Acute Construction Intruder (500 mrem)	0.89	0.80	0.67	0.45
Chronic Construction intruder (100 mrem/yr)	29.1	26.1	21.8	14.5
Rn Flux (20 pCi/m^2/s)	0.48	0.39	0.29	0.19
Atmospheric (10 mrem/yr)	1.1	0.51	0.22	0.05

The uncertainty analysis for the intruder, atmospheric releases, and radon fluxes indicates that the performance objectives are attained for all inventory scenarios except for the chronic intruder post-drilling scenario. The worst-case inventory is based on the assumption that the tank internals have been washed and the remaining heel is unaltered at a depth of 1 in. However, cleaning of Tank WM-182 has proven the effectiveness of the cleaning process, and the heel is much less than 1 in. The residual radionuclide inventory in Tank WM-182 is less than any of the inventories presented in the analysis. Also, the intruder doses are the result of short-lived radionuclides remaining after the end of institutional control. The analysis assumed that the intruder would drill through the reinforced concrete vault at 100 yr. Credit for the reinforced concrete vault deterring the intruder from drilling through the vault was not taken in the analysis. The doses are reduced dramatically because the time of intrusion is extended a few years.

The sensitivity/uncertainty analysis indicates that the conservative case analysis provides a "bounding analysis" of the potential doses to the public from the closure of the TFF. The sensitivity/uncertainty analysis indicates that the potential for the doses exceeding the performance objectives is low, and that a combination of worst-case assumptions would be required to result in the doses exceeding the performance objectives.

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5. COMPOSITE ANALYSIS SUMMARY

The TFF CA was conducted under HWMA/RCRA (State of Idaho 1983) and DOE Order 435.1 guidance (DOE 1999a) to evaluate the closure action of the TFF at INTEC. The CA is being submitted in conjunction with the TFF PA (DOE-ID 2003a) and this Tier 1 Closure Plan.

In accordance with DOE Guide 435.1-1 facility and site closure plan requirements,

> *…an assessment of the projected composite performance" of the TFF site must be performed as part of the closure process* (DOE 1999a).

This projected dose is compared with the DOE primary dose limit of 100 mrem/yr, total EDE, and the 30-mrem/yr dose constraint for a single source. The CA considers a 1,000-yr period after the TFF has closed to assess compliance with performance objectives (DOE 2001b).

5.1 General Approach

In support of the closure plan, DOE requires an assessment of the projected performance of the TFF with respect to performance measures (DOE 1999a). This assessment is completed in two documents: a PA and a CA. The purpose of the PA is to analyze data to determine the expected performance of a specific disposal facility, in this case, the TFF. A PA has been completed for the TFF closure (DOE-ID 2003a).

A CA is similar to a PA, but with a broader focus. The CA has been completed to support this Tier 1 Closure Plan for the TFF (DOE-ID 2003b). The methodology used to prepare the CA has been based on a logical sequence of steps as described by

- Guidance from DOE Order 435.1 (2001a), Manual 435.1-1 (2001b), and Guide 435.1-1 (DOE 1999a).
- *Department of Energy Deactivated High-Level Waste Facility Closure Federal Review Group Manual and Tier 1 Closure Plan Content Guide* (DOE 2000a)
- *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses* (DOE 1999b).

In addition, a CA for the RWMC at the INEEL was used to support the development of the TFF CA (McCarthy et al. 2000).

The initial step in performing a CA involves determining the scope and identifying applicable performance measures and relevant background/program information. The scope of the CA is to evaluate the cumulative impacts from active and planned disposal facilities and all other sources of radioactive contamination that could interact with the TFF to affect the dose to future members of the public. The primary dose limit of 100 mrem/yr, total EDE, is the basic performance measure. To prevent the potential dose from the aggregate of sources analyzed from exceeding a significant fraction of the primary dose limit, an administratively limited dose constraint of 30 mrem/yr is used.

The next step is to document relevant site characterization data and relevant features of the environment important to the development of conceptual models and the definition of analysis parameters. The relevant site characterization data and description of the environment are provided in the CA (DOE-ID 2003b).

All of the potential sources of contamination at the INEEL that could interact with the TFF closure releases are presented in the CA (DOE-ID 2003b). In addition, sources are screened from or included in the CA according to previous study results. The CA also presents a summary of the PA results (DOE-ID 2003b). Contaminant transport pathways were identified and a groundwater flow and transport model of the INEEL SRPA was developed. Contaminant releases were identified from previous studies and their impacts on the aquifer were quantified. In addition, the development of the all-pathways dose analysis methodology is presented and results are discussed.

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The remainder of the TFF CA presents an interpretation and evaluation of (a) the analysis of results in comparison to the performance measures and (b) the sensitivity and uncertainty of the analyses to ensure a reasonable expectation of performance.

The data quality objective (DQO) process (discussed in Section 6) is a flexible and adaptive approach that matches the type, quality, and quantity of data collected to the needs of the decision-maker for confidence in decisions that will be based on the data. DOE specifically directed DQOs be employed in the CA process.

Use of the DQO process will be critical to ensure that new data collection activities will satisfy data needs for the CA. The DQO process will be used for each sampling activity to be conducted during the closure activities for the TFF tanks. One of the data uses identified during development of the TFF tank sampling design was incorporation of the new data to the CA. As new data collection activities are designed, potential needs of the CA will be evaluated.

5.2 Source Term Development

The CA for TFF closure addresses all INEEL facilities and releases of radionuclides to the environment. Each of the facilities, or release sites, was described in the CA with the most recent data for radionuclide source terms and expected releases. In compliance with DOE Manual 435.1-1, Section II.U.(3)(a)(4), the CA includes

> *An assessment of the projected composite performance of all units to be closed at the site to the performance objectives and closure standards identified in the closure plan;*

Two pathways for radionuclide exposure to humans were considered: the air and groundwater pathways. Available data on all INEEL facilities were reviewed based on documented environmental releases. Two primary factors were considered in screening potential source terms for inclusion in CA models:

- Magnitude of source term based on dose and risk factors. Source terms that contributed minimal dose and/or risk were excluded from analysis.

- Impact to established groundwater flow paths based on regional hydrogeology and distance. If the source could not interact with contaminant plumes related to the closure action, based on either distance or groundwater flow patterns, then the source was excluded.

Previous investigations have identified sources of groundwater contamination from across the INEEL. The CA discusses the sources at each of these facilities and justifies their inclusion or exclusion from the CA analysis. Generally, sources were excluded based on groundwater flow paths, facility proximity to INTEC, or significance of dose contribution from the inhalation and groundwater pathways. Sources eventually excluded from analysis include those at Test Area North, Central Facilities Area, Waste Reductions Operations Complex/Power Burst Facility/Auxiliary Reactor Area, Naval Reactors Facility, and Argonne National Laboratory-West. The major sources of groundwater contamination included in the CA analysis are

- TRA warm water waste ponds
- INTEC injection well
- TFF
- Decontaminated bin sets
- RWMC
- WAG 3 soils.
- Decontaminated New Waste Calcining Facility

The CA provides specific radionuclide information for each of the identified sources (DOE-ID 2003b).

5.3 Analysis Methodology and Results

The CA presented detailed descriptions of the methods used to analyze the performance of the

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TFF facility and other contaminant sources at the INEEL

- Pathways and possible receptors (with the selection of the regional groundwater aquifer as the primary pathway)
- An overview of the analysis as performed
- Background information, including a discussion of the hydrology of the regional aquifer and the selection of the model code
- The conceptual flow model, including the calibration of the regional groundwater flow model and verification of the transport model
- A description of the sources modeled and the release rates to the transport model
- The all-pathways dose methodology and results.

5.3.1 Overview of Analysis

To evaluate the cumulative impacts of post-closure waste at the TFF combined with other sources, a numerical groundwater flow and transport model was developed. The computer code PORFLOW (ACRi 2000) was selected to predict the fate and transport of radionuclides in the aquifer. This model incorporated the regional aquifer flow system, including the release and transport of radionuclides from other facilities at the INEEL. The impact on groundwater resources resulting from the future release of radionuclides from the TFF is evaluated in combination with sources of contamination being released (or previously released in the past) from other INEEL facilities. Sources of contamination from the deactivated bins sets, INTEC WAG-3 soils, INTEC injection well, and the TRA warm waste ponds are modeled in conjunction with the TFF contaminant releases to the regional SRPA. In addition, doses for RWMC at the southern site boundary calculated in the RWMC PA (Maheras et al. 1994) and the RWMC CA (McCarthy et al. 2000) were included in the evaluation of composite dose. However, no release rates to the aquifer were available during the development of the CA for RWMC; therefore, contaminant transport simulations were not independently conducted for RWMC. The NWCF releases to the groundwater were not available from previous studies; however, predicted doses (Keck and Rood 2001) were included in the CA.

In all cases, the release and transport rates of contaminants in the unsaturated zone to the aquifer from the INEEL facilities were taken from prior studies conducted for each facility. The TFF release rates to the aquifer were evaluated in the PA for the TFF (DOE 2002b). Contaminant releases to the aquifer from the injection well, WAG 3 soils, and TRA warm waste ponds were evaluated in the WAG 3 RI/FS (Rodriguez et al. 1997). Release rates of contaminants from the deactivated bin sets to the aquifer were not available from previous studies. Therefore, to evaluate the potential future impact of releases from the deactivated bin sets, the release rates from the TFF tanks were used from the TFF PA (DOE 2002b) and scaled to the bin set inventory.

A regional groundwater flow model encompassing the southern portion of the INEEL and the area immediately downgradient was developed and calibrated for the CA using existing hydrologic information. This model incorporated hydraulic features of the basalt aquifer as described in the available literature and discussed in the CA. Using this calibrated flow model, tritium sources of contamination from the INTEC injection well and TRA warm waste ponds were input to the model and the resulting contaminant plume was calibrated with existing water quality data. Next, radionuclide release rates to the aquifer, taken from previous studies described above, were input to the model and the resulting contaminant concentrations at the receptor locations were evaluated. Finally, the groundwater concentrations were converted to doses using the all-pathways dose model.

In the all-pathways dose analysis, a member of the public is assumed to use water from a well for domestic purposes. The well is assumed to be located where the maximum concentrations of radionuclides in groundwater are predicted to occur. The majority of the contaminant releases occur at INTEC, including the TFF, WAG 3 soils, bin sets, and injection well releases. The only

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other source in the area is the TRA warm waste ponds, which release ^{3}H. Therefore, the point of maximum dose in this area would be near the INTEC releases, with potential minor contributions from the TRA tritium plume. The receptor was placed immediately downgradient, 100 m south of the location where the INTEC contamination was input into the model because all of the INTEC source releases were co-located at the TFF location. This receptor location is referred to as the INTEC receptor.

In addition to the INTEC receptor, the other potential location of plume interaction is at RWMC. The doses at the INEEL southern boundary determined in the RWMC PA and CA (Maheras et al. 1994; McCarthy et al. 2000) were combined with the doses from contaminants released from the INTEC and TRA facilities. The maximum predicted groundwater doses at the INEEL southern site boundary from the releases evaluated in this CA were combined with the doses 100 m south of RWMC. This receptor location is referred to as the RWMC receptor.

5.3.2 All-Pathways Dose Results

The dose at each receptor (i.e., INTEC or RWMC) for the low basalt and high basalt K_d values are provided. The compliance period for the analyses is considered to be at 2116 for INTEC, taking credit for institutional control. The compliance period for the RWMC receptor is at any time because the site boundary is being used to assess the doses and institutional control is not in effect.

Table 5-1 presents a summary of the peak all-pathways doses. The doses to the INTEC receptor are 2.8 and 0.15 mrem/yr for the low and high K_d cases, respectively. The doses for the RWMC receptor at the site boundary are presented as two peak values. The peak dose at 2010 years results from the predicted releases of ^{3}H from the TRA warm waste ponds and ^{3}H and ^{129}I from the injection well and WAG 3 soils. These doses were predicted as 1.8 mrem/yr and 1.3 mrem/yr for the low and high K_d value case, respectively. This dose is predicted to occur before releases from the TFF closure are predicted to occur at the RWMC receptor. The composite dose at the RWMC site boundary after significant releases begin for the TFF and deactivated bin sets occurs at 2900 for

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Table 5-1. CA all-pathways dose contribution summary from modeled sources.

Sorption Coefficient Used in Analysis	Receptor Location	Date of Peak Dose	Magnitude of Peak Dose (mrem/yr)	Major Contributing Radionuclides (%)
Low K_d values	Idaho Nuclear Technology and Engineering Center[a] (INTEC)	2847	2.8	^{129}I (94) ^{234}U (3.6) ^{238}U (2.9)
	Radioactive Waste Management Complex[b] (RWMC)	2010	1.8	^{3}H (75) ^{129}I (25)
		2900	0.2	^{129}I (100)
High K_d values	INTEC	2856	0.15	^{129}I (99.3) ^{234}U (0.4)
	RWMC	2007	1.3	^{3}H (100)
		3017	0.04	^{129}I (100)

a. INTEC receptor located 300 ft (100 m) downgradient of the model input location for the INTEC sources.

b. RWMC receptor located at the southern INEEL boundary, along the predicted pathway of the plume, with the addition of RWMC doses located at 300 ft (100 m) south of the RWMC facility as reported in McCarthy et al. (2000).

the low K_d value case with a dose of 0.2 mrem/yr and at 3017 for the high K_d value case with a dose of 0.04 mrem/yr. These predicted doses do not include the contributions from the NWCF or the RWMC releases. The addition of these sources to the composite dose at each receptor is discussed in detail in the CA (DOE-ID-2003a).

5.4 Performance Evaluation

The CA provides the results of the sensitivity and uncertainty analysis for the models and assumptions upon which the CA was based. The major cause of uncertainty is related to a lack of data. However, conservative assumptions based on the best data available mitigate the uncertainties associated with the analyses.

5.4.1 Comparison of Results to Performance Objectives

The CA contains an in-depth comparison of the CA results to the performance objectives, which are summarized in this section.

The total predicted dose to a hypothetical future member of the public was compared to both the DOE primary dose limit of 100 mrem/yr, and to the CA dose constraint of 30 mrem/yr. The predicted all-pathway doses to a hypothetical future member of the public were compared to the dose constraints described for the two receptor locations: INTEC and RWMC.

Two sets of groundwater simulations were conducted to evaluate the transport of radionuclides from the INTEC facility via the regional groundwater flow system. One set of simulations used distribution coefficients (K_d values) set at the lower end of those presented for basalts, and the other set of simulations used K_d values at the upper end of the basalt or sand range, whichever was higher. The all-pathways doses from the groundwater pathway are presented in Table 5-1 and discussed fully in the CA (DOE-ID 2003b).

The maximum all-pathways dose of 2.8 mrem/yr was found for groundwater simulations with low K_d values at INTEC in the year 2847. The maximum all-pathways dose contribution from the INTEC modeled sources at RWMC was predicted to be 1.8 mrem/yr in the year 2010. The major source of this dose is early releases from the injection well and WAG 3 soils. The predicted dose at RWMC when the releases from the TFF and deactivated bin sets are significant was determined to be 0.2 mrem/yr in the year 2900. By this time, the dose from the injection well and WAG 3 soils is not significant.

Release rates to the aquifer from the RWMC facility were not available. However, doses are presented in the RWMC CA (McCarthy et al. 2000). The largest dose at the RWMC receptor was reported as 29 mrem/yr in the year 2596. The largest predicted all-pathways dose was from ^{14}C, with a maximum dose of 24.3 mrem/yr in the year 2646 (McCarthy et al. 2000). The doses from the RWMC facility are less than 25 mrem before the year 2400. The dose contribution from the TFF CA is less than 0.1 mrem/yr at the RWMC receptor before this time. After 2400, the maximum dose contribution from the TFF CA is 0.2 mrem/yr while the maximum contribution from the RWMC facility dose is 29.0 mrem/yr. Therefore, the combined doses from the TFF and RWMC CA analyses would be, at a maximum, 4.8 mrem/yr for the year 2010 and 29.2 mrem/yr in 2900.

In all cases, the predicted all-pathways dose is less than both the DOE primary dose limit, 100 mrem/yr, and the CA dose constraint, 30 mrem/yr.

5.5 Allocation of Performance Objectives

The PA provides an evaluation of the expected future performance of the closed TFF with respect to specific performance measures. Conduct of the PA involved developing a conceptual model of the facility and surrounding environment, determining the radioactive inventory in the waste, identifying exposure scenarios and pathways, and performing dose analyses based on these scenarios and pathways. The dose assessment developed under the PA and CA must generate a credible, objective, realistically-balanced analysis; include

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information on hazard, exposure, and dose; and delineate uncertainties and assumptions used in the dose assessment.

The results of the PA analyses were then compared to performance measures. In addition, a sensitivity and uncertainty analysis of the results was conducted. The CA was conducted using a similar approach, but with a broader focus than the PA.

The CA provides a reasonably conservative assessment of the cumulative impacts from active and planned INEEL LLW disposal facilities, and all other sources of radioactive contamination that could interact with the closed TFF to affect the dose to future members of the public. The CA includes sources of radioactive material that could interact with the closed TFF facility. The CA provides information that DOE can use for planning.

The CA provides a suggestion of what could conceivably happen if DOE did not act, beyond the actions assumed in the CA, to protect public health and safety. DOE can decide on the best ways to manage the total disposal system and expend its resources accordingly. For example, DOE can identify those sources that most significantly contribute to total projected dose and decide on priorities for remediation or closure alternatives for active or inactive disposal areas. Hazard implications for some sources may be so low that little needs to be done beyond land use control, minor maintenance, and monitoring.

The requirement for this Tier 1 Closure Plan is that a strategy, or methodology, for apportioning the performance objectives and closure standards identified in DOE Manual 435.1-1, Section II.U.(3)(a)(1), to each of the facilities or units to be closed at the site is identified (DOE 2001b). This strategy defines how facility or unit-specific performance objectives are, or will be, established based upon the overall site performance objectives. The strategy provides reasonable assurance that the overall performance objectives will not be exceeded by either the summation of the individual facility closure actions or by future closure activities. Additionally, the method recognizes that constituents of concern (radionuclides or chemicals) from various facilities or areas may impact compliance points at different times because of varying closure scenarios and geological conditions. The performance standards for the closure of a deactivated HLW facility are concentration, or dose, limits for specific radiological or chemical constituents released to the environment. These standards apply to various environmental media, at different points of compliance, at various periods during or after closure.

The analyses presented in the PA were based on conservative assumptions and a bounding radionuclide inventory for each tank. The bounding inventory was used as the starting point for the calculations to determine if limits were required on any given radionuclide in the TFF tanks.

The entire limiting 4-mrem/yr performance objective budget was allocated to the TFF closure. This is considered appropriate because all tanks to be closed are located within close proximity to one another. In other words, closure of facilities located in separate hydraulic flow regimes does not apply to the TFF closure. As demonstrated in the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (Westinghouse Savannah River Company 1992), several facilities were considered during closure that were not within the same groundwater transport segments. The TFF is located within a flow regime in which all contaminants were considered within the specified groundwater transport segment modeled in the PA. Therefore, differing performance objective budget allocations for each tank are not necessary.

The two-dimensional groundwater transport model considered a 3-ft (1-m) slice through the major axis of the tanks, resulting in a north-south cross section. This ensured that the maximum unit area of waste was input in the model and the downgradient groundwater concentrations would be representative of the centroid of the contaminant plume that would be realized in a three-dimensional model (i.e., the maximum downgradient groundwater concentrations were estimated). Using a bounding radionuclide

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inventory, conservative transport assumptions, and selecting the maximum unit area of waste slice resulted in a hypothetical maximum dose. That is, potential contributions from other slices would be more than offset by lateral dispersion from the selected worst case slice and would, therefore, not result in a combined dose greater than that estimated. In other words, the allocation of performance objectives is implicitly not needed, as the worst case combined dose is within the total performance objective and reflected in the conservative analysis presented in the PA.

Management of the PA and CA process is dynamic and must be continued over the entire lifetime of the facility, up to the time of unrestricted release of the site. Therefore, specific objectives and approaches of the PA and CA may change over the life of the facility. To date, DOE has focused on completing PAs and CAs for existing LLW facilities and sites that have received waste since September 26, 1988. These assessments and analyses have been developed using existing information on past activities and expected future activities, including closure, and recognize that uncertainty exists in the information. As part of the maintenance process, PAs and CAs are refined and updated as new information becomes available that reduces uncertainty.

Dose assessment results in the development of quantitative and qualitative estimates of dose for all nuclides of concern. Dose assessment is not complete unless the numerical estimates are accompanied by information that interprets and qualifies the results. Analysis of sensitivities and uncertainties is the last, and potentially the most important, step in conducting the PA and CA.

The first, and possibly most important, parameter to be developed in an evaluation of dose is the contaminant-specific concentration term. Contaminant concentrations are used directly in soil ingestion and direct radiation pathways and as an input to other pathways (e.g., groundwater ingestion and particulate inhalation). For purposes of the CA, spatial distribution of the contaminants was a critical factor in determining which sites to include or exclude from the analysis. The CA included all sites that may leave a radioactive source term whose plume may interact with the residual plume. These potentially include contaminants in WAGs 2, 3, 4, 5, 6, 7, and 10; residual radioactivity from future decommissioning actions; and HLW facility closures. Doses at most individual release sites have been previously evaluated under CERCLA. Sites with no significant source term were screened from further evaluation in the CA.

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6. CLOSURE SAMPLING

Post-decontamination sampling and analysis will be performed during the various TFF closure phases to demonstrate compliance with applicable closure standards.

6.1 Data Quality Objectives

DOE Order 435.1 requires waste to

> *…be characterized using direct or indirect methods, and the characterization documented in sufficient detail to ensure safe management and compliance with waste acceptance requirements of the facility receiving the waste* (DOE 2001a).

The order also requires the use of a DQO process to identify characterization parameters and acceptable uncertainty in characterization data. The order specifies that characterization data shall include, at a minimum, the following relevant information:

- Physical and chemical characteristics
- Volume, including the waste and any solidification media
- Radionuclides or source information sufficient to describe the approximate radionuclide content of the waste
- Sufficient chemical and physical data to clearly identify any hazardous characteristics that may degrade the ability of structures, systems, and components to perform their radioactive waste function.

The DQO process, developed by EPA in *Guidance for the Data Quality Objectives Process* (EPA 2000), was used to design the sampling activities during closure of the TFF. The process is applied to ensure that the type, quantity, and quality of data used in decision-making are appropriate for the intended application. A detailed discussion of the DQOs for Phase 1 is presented in the *Sampling and Analysis Plan for the Post-Decontamination Characterization of the WM-182 and WM-183 Tank Residuals* (Portage Environmental 2002). The DQO process includes seven steps, each of which has specific outputs.

The overall objective of the post-decontamination characterization is to obtain data that can be used to determine if decontamination activities have resulted in the TFF meeting the DOE Order 435.1 and HWMA/RCRA closure requirements. If the residual waste remaining in the TFF at final closure is hazardous waste (i.e., either characterized by toxicity or by corrosivity) in accordance with 40 CFR 261 (2002), then the TFF must be closed as a landfill under HWMA/RCRA. For the TFF to be clean closed, the concentrations of hazardous constituents associated with the listed waste codes currently attached to the tank waste also must be below action levels. Following the closure of all TFF tank systems, the mean concentrations for constituents remaining in the residuals in all tanks, and other system components, will be used to determine if the clean-closure specifications stated in the closure plan have been met.

Table 6-1 lists the radionuclides that provide the greatest dose contribution as analyzed in the PA (DOE-ID 2003a). The results of post-decontamination sampling will be compared to the total Ci quantity by tank (radionuclide inventory) to determine if the tanks have been cleaned to meet the performance objectives shown in the PA.

Table 6-1. Radionuclides that provide the greatest dose contribution according to the TFF performance assessment.[a]

Radionuclide	Total Activity (Ci)
^{14}C	4.9E–01
^{137}Cs	4.0E+03
^{129}I	2.6E–03
^{90}Sr	8.0E+03
^{99}Tc	1.0E+00

a. Source: DOE-ID 2003a.

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If the post-decontamination characterization data indicate a Ci quantity by radionuclide that is significantly greater than that shown in Table 6-1, additional analysis will be performed. This additional analysis will evaluate the exposure scenarios(s) where the radionuclide has been shown to be a significant contributor. The analysis will compare the predicted radiation dose to the actual radiation dose based on the revised radionuclide inventory.

6.2 Sample Collection

The process for post-decontamination sampling of all tank solid and liquid residuals is discussed, specifically for Phase 1, in the *Sampling and Analysis Plan for the Post-Decontamination Characterization of the WM-182 and WM-183 Tank Residuals* (Portage Environmental 2002).

6.3 Data Validation and Reporting

After field data collection and laboratory analysis, a series of evaluations and data reduction steps will be conducted to ensure that the data are acceptable and useable.

Data reduction is the process of converting raw data into a useable form for interpretative purposes for environmental risk assessment and verification of closure design. Laboratory deliverables include raw and reduced data to ensure complete documentation of all aspects of laboratory analysis, permit independent verification of reported results, provide a form of data that is technically and legally defensible, and ensure that the end data user can be completely confident in the results. Scientists and regulators within DOE and DEQ may review data to ensure compliance with HWMA/RCRA and DOE closure requirements.

Data validation is used to determine whether or not the analytical data meet the project DQOs and to determine if the data are technically and legally defensible and reliable. Data validation is the comparison of analytical results versus the requirements established by the analytical method. The applicable analytical method quality control guidelines are used to validate data with the exception of radiological data, which will be validated exclusively using ER-TPR-80 (INEEL 1997). The final product of the validation process is the validation report, which communicates the quality and quantity of data to the data user.

6.4 Data Uses

Closure data will be used to make decisions relative to DOE closure and HWMA/RCRA clean closure. Initially, the concentration variance and sample mean for each constituent of concern will be calculated. For hazardous constituents, these data will also be used to calculate the 95% upper confidence limit (UCL) of the sample mean, which is a conservative estimate of the population mean. The concentration corresponding to the 95% UCL will be compared to HWMA/RCRA action levels to determine if clean-closure performance standards have been met within the decisional errors specified in the DQOs. The radionuclides will be compared to the source term analysis, provided in this document, to ensure the source term levels are not exceeded. These data will be used at final closure (in the year 2016) as part of the final TFF radionuclide source inventory by averaging available data from all phases of closure.

6.4.1 Updated Source Inventory

The source inventory will be updated at final closure with data from all proceeding closure phases. Closure activities are designed to remove as much of the residual waste in the tanks and systems as possible. Constituent concentration data collected during closure, as represented by the 95% UCL, will be used to update the source inventory.

The waste in the TFF tanks contains radionuclide species that will not be directly measured during execution of activities specified in the sampling and analysis plan (Portage Environmental 2002). This is because analytical methods don't exist for these radionuclides or analysis is cost prohibitive. For these additional species, ORIGEN2 will be used to estimate the activity levels. The results of the simulation will

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be used in the updated closure inventory, along with measured activities, by normalizing the results of the simulation to 1.0 for ^{137}Cs, similar to the methodology used in estimating the current radionuclide inventory. The inventory will be based on the 95% UCL from samples collected directly from the residual waste in the TFF. The updated source inventory will be used to further analyze the performance of the closed TFF.

6.4.2 HWMA/RCRA Clean Closure

The action levels established for the TFF will be compared to data collected after decontamination of the tanks and ancillary equipment. The action levels were developed by calculating concentrations of constituents using a risk-based approach.

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7. CLOSURE DESIGN ALTERNATIVES

Alternative methods for removing waste and waste residuals from TFF equipment have been evaluated in feasibility studies. Results of these studies were compared and incorporated in the TFF closure conceptual design (INEEL 2000b) and the project technical and functional requirements. Additional waste removal techniques were studied using full-scale waste removal and residual solidification mock-up tests. The results of these tests were incorporated in the conceptual design and process description contained in this document.

A study also was completed in 1989 on the decontamination of the existing 300,000-gal tanks at INTEC.[a] The configuration of the underground tanks, and physical and radiological constraints, requires the use of remote access and handling technologies.

7.1 Tank Heel Removal

The first step in tank decontamination is the removal of the tank heel, also known as sludge or residual. A description of the removal options follows. Equipment described for several sludge removal options addresses only the function of mixing or moving the solids within the tank. In these cases, a steam jet pump is used for removing or transferring material from the tank.

7.1.1 Mixer Pump

In the first option, mixer pumps agitate the sludge and discharge it within the tank. The pump is suspended on a shaft from the top of a riser and is designed to continuously rotate so that the discharges cover a full circle. Two types of pump systems were evaluated: a single large mixer pump and four smaller mixing pumps.

The advantage of using of a mixer pump is that it is a proven method.[a] There has been successful scale-model testing at the West Valley Demonstration Project, New York, and successful full-scale demonstration at the Savannah River Site (Westinghouse Savannah River Company 1992). Sludges at both of these locations were more difficult to move than those at the TFF will be. Also, one large mixer pump located near the center can cover the entire bottom area of TFF tank.

The disadvantages of using of a single, large mixer pump are that a new 28-in. riser is required for access and the sludge in tanks with cooling coils may not be sufficiently agitated.[a]

The alternative to a single, large mixer pump is to use up to four smaller mixer pumps in each tank. This option may use high-speed or low-speed pumps.

The advantage of using smaller pumps is that they can be inserted through the 12-in. risers. In addition, the low-speed, small pumps are more durable with less risk of equipment failure. The lower-speed pumps may not require bearing flush (which introduces fresh water, increasing the volume of contaminated liquid).

The disadvantage of using smaller pumps is the uncertainty as to whether or not the sludge and heel over the entire bottom area of the tank could be successfully agitated because lower speed pumps have limited capabilities.

The tanks with cooling coils on the floor would limit the effectiveness of this system. During the closure, one or more mixer pumps would likely have to be removed to allow entry for a transfer pump, for equipment to clean or decontaminate tank walls, and for a video camera to check progress.

7.1.2 Slurrying System

For the second option, slurrying system would integrate sludge agitation and slurry transfer functions.[a] This system incorporates an aboveground, liquid-feed pump supplying two or

a. Letter from Stearns-Roger Co. to DOE, 1989, "Special Study for Decontamination of Existing Tanks," SRD-11/10/89-1, November 1.

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three hydraulic oscillating jet nozzles (to resuspend the sludge) and a slurry transfer pump.

Slurrying system advantages include

- A separate transfer pump to lower the liquid level near the tank's bottom may not be required.
- Single vendor is responsible for a complete system that performs both sludge and liquid heel removal.
- Hydraulically-actuated jet nozzles powered by a pump outside the tank would minimize the risk of equipment failure. While this system has many deficiencies for nuclear sludge removal, the use of oscillating nozzles fed by a pump outside the tank merits further consideration.

Slurrying system disadvantages include

- Slurrying transfer pump can reduce the heel level only to 4 in. (10 cm).
- A new 28-in. riser is required for access.
- The sludge in all areas of the tanks with cooling coils may not be resuspended.
- Some features of the system are unacceptable (e.g., slurry transfer pump motor is within the tank). Modifications would make this a custom system, which requires development and testing.
- The tank risers are not large enough to accommodate this type of system.

7.1.3 Robotic Arm with Spray Nozzle

This option involves sluicing the sludge material toward the steam jets in contrast to suspending the solids throughout the tank liquid (i.e., the mixer pump option) (see footnote a, page 7-1). A robotic arm, which would direct a flexible liquid supply line and spray nozzle, would be inserted into the 12-in. riser closest to the tank's center. With a liquid supply of 200 gal/min (800 L/min) and 200 psig at the nozzle, an effective range of over 30 ft (9 m) can be achieved for sluicing the material. Advantages of this option include

- The robotic arm can also be used for tank inspection. However, the inspection arm must be capable of carrying the load of the spray nozzle and flex hose. This load does not appear to be excessive if the flex hose is properly mounted. The proper design of the directional nozzle would minimize the thrust load to the robotic arm.
- A reduction in time and water usage can be realized by using steam jets at all available 12-in. risers. Only one steam jet at a time needs to be operated. The robotic arm can be used to push the sludge toward each steam jet. The liquid flow rate of the directional nozzle would be balanced with the steam jet's flow rate.
- The robotic arm and spray nozzle can also be used to rinse all tank interior surfaces after the sludge is removed. Dual use of the robotic arm and directional nozzle will eliminate equipment cost and installation of separate tank-cleaning machines.
- Most of the other removal alternatives will require that a robotic arm be installed at some stage of decontamination to visually check for complete sludge removal. This method combines both removal and inspection.

Disadvantages of this option include

- The cooling coils along the tank bottom will interfere with sluicing. The coils will deflect the stream and not allow complete coverage. Video observations of a tank during washing showed that the sludge can be moved under the coils. However, the coil supports on the tank bottom may impede movement. Thus, this method of sludge removal may not be as effective in complete cleaning as a method that puts the sludge in suspension (i.e., mixer pumps).
- A large area of the tank floor is not accessible through the tank risers. Sludge in this area

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must be moved a significant distance to the nearest steam jet. There are sections in the tank where the sludge must flow opposite or perpendicular to the nozzle direction to reach a steam jet. It may be necessary to move the robotic arm several times or to rely on deflection of the stream on the tank walls to achieve complete removal.

- This option would require design of a new robotic arm to direct the nozzle.

7.1.4 Directional Nozzle

Tank cleaning systems are available that use a remotely-directed nozzle. The nozzle direction rotates 360° around the vertical axis and through a vertical arc approaching 160° from straight down (see footnote see footnote a, page 7-1). The assembly may include a video camera to allow visual feedback. Control can be manual or pre-programmed. The use of the manway located in the central area of the tank is preferred to minimize the distance to the furthest tank wall. Advantages of this option include

- Directional nozzles have proven success at sluicing difficult sludges. Also used to remove sludge and clean tanks at Oak Ridge National Laboratory.

- For tanks with bottom cooling coils, a directional nozzle may perform better than the mixer pumps or the slurrying system at removing sludge from the tank bottom because the nozzle is mounted above the heel. The spray nozzle offers some ability to vary the "angle of attack."

- One nozzle located near the center can reach and wash the entire tank.

- A directional nozzle system could also be used to wash, chemically clean, and rinse the tank walls effectively.

- Directional nozzle systems do not require long, rapidly rotating shafts within the tank and should operate more reliably than mixer pumps.

Disadvantages of this option include

- The directional nozzle cannot move horizontally from the machine's vertical axis; as such, the nozzle will not perform as well as the robotic arm with the nozzle. The robotic arm nozzle is more effective at washing the tank walls behind the cooling coils.

- Interference from cooling coils and supports may limit the quantities of sludge removed.

7.1.5 Use of Compressed Air

Under the fifth option remote-controlled vehicle (or "submarine") would be required to position a lightweight compressed air hose to push the sludge toward a siphon (see footnote see footnote a, page 7-1). Vehicles for this use are made small enough to be inserted through a 12-in. riser but are limited to a small thrust of approximately 5 lb. A vehicle capable of positioning a flexible air hose for this application must have a thrust capability of 30 to 40 lb. A vehicle that measures 20 × 18 × 38 in. (50 × 46 × 97 cm), which also must be inserted through the tank manway, would be required. These vehicles are commonly used in the nuclear power industry for inspection of reactor vessels and are equipped with video capabilities.

No unique advantages of this option were identified. Disadvantages of this option include

- The usefulness of the video camera for tracking the vehicle will be minimal in liquid that is clouded by suspended sludge. A second video camera mounted on a robotic arm above the liquid surface is needed to track the vehicle. Special filters also may be needed on the camera to minimize surface reflection.

- Sludge removal will be a slow process with the equipment's limited size and the large area to cover. More than one vehicle can be used but this will increase the quantity of air entering the tank that must be removed by the existing vent system.

- To maneuver the vehicle, a liquid level of 2.5 to 3 ft (0.76 to 0.9 m) must be maintained

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during sludge removal. A water supply is needed at a flow rate matching the sludge discharge rate to maintain this level.

- Sludge particles suspended in the liquid near the vehicle will pass through the thrusters, and abrasion of the thrusters may pose operating difficulties.

- Tanks with cooling coils located on the floor and walls would limit the effectiveness of this system.

7.1.6 Use of Vacuum

In the sixth option, flexible suction line would be used to evacuate the sludge. The line would be positioned with the use of a remote-controlled vehicle. The suction line would be connected to a steam jet, and the steam jet would be positioned above the liquid level to allow room for movement of the flex hose.

The vehicle would need to be modified to connect it to the flexible hose. This connection must be secure enough to keep the vehicle and hose together when being inserted into the tank and during sludge removal. The connection should be flexible enough to allow the vehicle to travel over the rows of coils yet allow the end of the hose to rest on the tank bottom. The vehicle must pull the hose over each row of coils as it travels from one coil space to the next. A vertical sump pump could be used as an alternative.

No unique advantages were identified for this option. Disadvantages of this option include

- The liquid level must be maintained at 2.5 to 3 ft (0.76 to 0.9 m).

- The vehicle camera will have limited use. An additional camera above the liquid is needed and this camera may have difficulty producing clear images.

- Sludge removal will be slow.

- Abrasion of vehicle thrusters may pose operating difficulties.

- Tanks with cooling coils on the floor and walls would limit the effectiveness of this system.

7.1.7 Bottom Crawling Scavenger

This option is usable for Tanks WM-184 and WM-186, which do not contain cooling coils and have 18-in. tank access risers. Sludge from these tanks could be removed by a track-driven vehicle equipped with rotary brushes, camera, suction hose, and optional spray jets. A device called the "superscavenger" is remotely controllable to remove bottom sludge. The sludge collected by the moving vehicle is pulled through a flexible hose by a vertical sump pump or steam jet. The pump is located inside the tank above the tank bottom to allow free movement of the hose. The pump motor is located above the tank. Advantages of this option include

- This equipment will not fit through a 12-in. access riser but will fit through the 18-in. size opening. The riser location is not critical.

- Compared to other options, the equipment is relatively inexpensive and can be transferred easily from tank to tank.

- Removal of sludge is relatively quick. A 65-ft diameter tank with 3-in. (8-cm) thick sludge can be cleaned out in 8 to 10 hr.

- The equipment can be configured to clean vertical walls.

- The equipment is proven technology and commonly used in the nuclear industry for tank cleaning.

Disadvantages of this option include

- The existing "superscavenger" is not designed for traveling in a tank containing cooling coils, but it may be possible to design and build a modified unit that can do so. The equipment supplier would require detailed drawings of the coil arrangement to investigate this possibility. Further pursuit would involve design, development, and testing.

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- The vehicle can encounter problems if it cannot get adequate traction to move in deep sludge. Whether or not this is a problem is unknown. A simulation of sludge removal at the anticipated depth and material characteristics to be encountered should be conducted.

- As in the other options, water must be supplied to maintain pump suction head.

- The equipment supplier can provide equipment that will separate the solids from the liquid after removal from the tank. However, this equipment is designed to separate particles 44 μm and larger and, as such, has little use in this application.

- Tanks with cooling coils located on the floor and walls would limit the effectiveness of this system.

7.1.8 Flexible Hose

For the eighth option, pressurized flexible hose is inserted through any of the 12-in. risers. A nozzle at the end of a hose(s) moves randomly (in a snake-like manner) as a result of the pressure, thereby agitating the solids. The agitated solids are made available for removal by the steam jets. Advantages of this method are simplicity, minimal expense, and ability to use the existing 12-in. access risers.

Disadvantages of this option include

- Uncertainty in the equipment's ability to perform complete sludge removal. The method will work much better in the tanks that do not contain cooling coils. Simulation and testing would be essential in either tank configuration before use.

- This nozzle moves in a random pattern, which may not cover some areas of the tank. A directed or predetermined pattern would be more practical, and use less water.

7.1.9 Air Agitation Using Cooling Coils

This option is usable only in tanks that contain the elaborate network of cooling coils (WM-182, WM-183, and WM-185). Before sludge is removed, the liquid level must be drawn below the level of the bottom coils. A robotic arm is then inserted through a 12-in. riser and cuts several holes in the cooling coil along the tank bottom. The robotic arm must be inserted and removed from all available 12-in. risers to reach the cutting locations. After the holes are cut, the robotic arm is removed. The holes would be positioned at an angle toward the tank bottom. The cooling coil piping outside of the tank would be modified and connected to a compressed air supply.

Inlet air for the compressor would be provided from the waste tank to eliminate external air filtering and condensing equipment but doing so will risk leakage. If this risk is too great, the alternative is to use fresh ambient air to the compressor and exhaust the air through the existing tank vent system, provided it has adequate capacity. The air quantity and pressure estimated is 1,000 acfm at 50 to 60 psi through the cooling coils. This is based on information from tanks at the Hanford, Washington, DOE facility that exceed 1 M gal and require 500 acfm at 50 psi to maintain the sludge in suspension.

The liquid and suspended solids are removed by an existing steam jet. To maintain a constant level for solids suspension, a clear liquid (water) make-up supply is needed. The mixture will then gradually become clear as the solids are purged. Advantages of this option include

- Potential of a more complete solids removal from all surfaces of the tank bottom and it would require only the existing 12-in. access risers

- The coils with holes could be used to distribute heated air for the final drying step of decontamination.

Disadvantages of this option include

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- The cost of equipment and labor needed to remotely cut the cooling-coils would be high.

- The time required to modify the coils before sludge removal will be lengthy. The sludge level must be sufficiently low to allow access to cut the coils. The cooling coils need to be drained and disconnected before modification begins.

- Radiation hazards will exist during transfers of the robotic arm from one riser to the next and during operation of the air compressor.

- Additional tank gas venting equipment may be needed if the compressor is to use fresh ambient air. This entails the design of an expensive piece of equipment for remote cooling-coil cutting.

In conclusion, the results of the TFF sludge removal options study resulted in the development of the closure design described in Section 2.

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8. CLOSURE CONTROL PLANNING

Final facility and site closure activities are intended to stabilize the site and minimize the need for ongoing active maintenance. At the end of the closure period, the facility or site is in a condition where only institutional control, including site monitoring, is required. This section discusses closure control planning for the INEEL and the proposed TFF closure.

8.1 INEEL Land Use Planning

A significant level of planning for facility and land use has been completed at the INEEL that has a direct impact on establishment and maintenance of closure controls for the TFF. The INEEL planning framework starts at the DOE level with strategic plans and mission strategic plans and then, at the INEEL level, with institutional plans, infrastructure long-range plans, and strategic and tactical plans. Supporting this planning structure are plans addressing specific issues (e.g., the *Idaho National Engineering and Environmental Laboratory Comprehensive Facility and Land Use Plan* [DOE-ID 1997], the *INEEL Environmental Management End State Plan* [INEEL 1998], the *FY 2001-2005 INEEL Institutional Plan* [INEEL 2000c], and the *Idaho National Engineering and Environmental Laboratory Infrastructure Long-Range Plan* [INEEL 2001d]). In addition, the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002) provides a description of land-use planning specifically referencing the *Facility and Land Use Plan* (DOE-ID 1997). Additionally, the INEEL recently published *INEEL Long-Term Stewardship Strategic Plan* (DOE-ID 2002c). This plan establishes the need for, and strategic goals and objectives of, a single, consolidated long-term stewardship program for the INEEL.

To facilitate decisions about ER activities at the INEEL, DOE conducted analyses to project reasonable land-use scenarios at the INEEL for the next 100 yr. Completed in 1995, the methodology for generating the scenarios included reviewing existing DOE plans, policy statements, and mission statements pertaining to the INEEL; reviewing surrounding land-use characteristics and county development policies; soliciting input from local, county, state, and federal planners, policy specialists, environmental professionals, and elected officials; and reviewing environmental and development constraints that could influence future land use at the INEEL.

The *INEEL Comprehensive Facility and Land Use Plan* is presently being revised to reflect the latest ER, waste management, and research and development planning including the *HLW and Facilities Disposition Final EIS* (DOE 2002). The revision, scheduled to be complete in September 2003, will include the TFF closure activities as described in this closure plan.

These analyses resulted in the development of specific issues, assumptions, and constraints that guided the generation of facility and land-use scenarios in 25-yr increments for 100 yr, as published in the *Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995).

The planning assumptions include

1. The INEEL will remain under government management and control for at least the next 100 yr. The implementation of this management and control becomes increasingly uncertain over this time period. Regardless of the future use of the land now occupied by the INEEL, the federal government has an obligation to provide adequate institutional controls (i.e., limit access) to areas that pose a significant health or safety risk to the public and workers until that risk diminishes to an acceptable level for the intended purpose of the land. Achievement of this obligation hinges on the U.S. Congress to appropriate sufficient funds to the responsible government entity charged to maintain the institutional controls for as long as necessary.

2. Advances in DOE and private-sector research will result in the obsolescence of

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existing facilities. Further, it is assumed that new facilities will need to be constructed in response to the need to provide state-of-the-art research facilities. Other programs, however, will be discontinued entirely after the facilities become obsolete.

3. As contaminated facilities become obsolete, D&D will be required. Similarly, contaminated areas will require remediation. The D&D process will commence following closure of a facility once it has been determined that the facility is no longer needed and sufficient funds are appropriated to safely accomplish the work.

4. New construction may include new structures in existing facility areas and development of new facility areas. Development should be restricted to core areas already established.

5. To the extent practical, new development will be encouraged in established facility areas to take advantage of existing infrastructures. Such development will reduce environmental degradation associated with construction activities in previously undeveloped areas.

6. The Central Facilities Area will remain the focal area for support and infrastructure activities, assuming continuity of existing or similar INEEL missions.

7. ER and waste management activities will continue. Cleanup of hazardous, mixed, and LLW sites is expected to be completed within 10 yr following completion of a ROD for the cleanup mandated by CERCLA.

8. Research and development facilities will be expanded to accommodate "new frontier research." To support such efforts, cooperative partnerships between the public and private sectors may be developed to achieve mutual goals. This could result in the re-use of INEEL facilities by private-sector interests, supplemented with technology support by INEEL personnel.

9. The INEEL may be called upon to support defense-related operations.

10. Regional development trends will be closely related to activities at the INEEL. The weight of the INEEL's influence on the region may increase or decrease over time depending on the diversity and strength of the regional economy.

11. No residential development (i.e., housing) will occur within the INEEL boundary. However, grazing will be allowed to continue in the buffer area.

12. No new major, private developments (residential or nonresidential) on public lands are expected in areas adjacent to the INEEL. There is uncertainty about the applicability of this assumption to privately-held land. Beyond 25 to 50 yr, there is less certainty about this assumption.

13. An 890-mi^2 (2,300-km^2) site dedicated to nuclear research, development, testing, evaluation, and environmental management is irreplaceable. Therefore, it is unlikely that the siting of a similar DOE facility and land withdrawal would occur in the future at any other location in the contiguous 48 states.

14. New locations for LLW disposal may need to be identified. If new locations are needed, they will be subject to regulatory approval processes.

15. In accordance with DOE Order 1230.2 (DOE 1992), DOE recognizes that a trust relationship exists between federally recognized Tribes and DOE. DOE will consult with Tribal governments to ensure that Tribal rights and concerns are considered before DOE actions, decisionmaking, or program implemention that may affect the Tribes.

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Consistent with the intent of planning assumptions 1 through 13, previously listed, INEEL land-use plans are formulated under the premise that the INEEL site, as it currently exists, should remain intact for the foreseeable future. The abstract of the *Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995) supports this supposition by stating,

> *These scenarios project...no change to the present INEL boundaries within the 100-yr period....*

The land-use scenarios for the various INEEL facilities are summarized in Table 8-1 and shown in Figures 8-1 through 8-4.

8.2 Monitoring

Existing INTEC groundwater (aquifer and perched water) monitoring well locations at the INTEC are illustrated in Figure 8-5. In February 2001, the INEEL received a request from DEQ for a post-closure permit application of the INTEC WCF (located just south of the TFF). The primary focus of the letter request was the inability to reach agreement on how to meet HWMA/RCRA post-closure monitoring requirements through the FFA/CO ER Program. Therefore, the WCF post-closure permit application will address post-closure monitoring requirements, including

- The number, location, depth, and construction of groundwater monitoring wells
- The procedures for sample collection, sampling frequency, sample preservation, shipment, analysis, and chain of custody control.

Because the TFF is also being closed under HWMA/RCRA requirements, issuance of the WCF post-closure permit will substantially define TFF monitoring requirements. The post-closure monitoring program would begin when the final closure is complete in 2016. The program will be designed to include the elements specified in DOE Manual 435.1-1, R.(3)(a), which are media, radionuclides, and locations (DOE 2001b). Appropriate key radionuclides, as defined by DOE M 435.1-1 (DOE 2001b), and those identified by the PA and CA (DOE-ID 2003a, 2003b) (e.g., ^{129}I), will be among the constituents included in the TFF closure monitoring program.

8.3 Access and Institutional Control

Institutional control measures for WAG 3 (which surrounds the TFF) are described in *Institutional Control Plan for the INTEC, WAG 3, OU 3-13* (DOE-ID 2000c). Specific institutional control measures for the TFF and OU 3-14 (intermingled with TFF facilities) will be finalized in, at, or near the end of closure.

8.4 Maintenance

Maintenance activities associated with the closed TFF will include inspections, controlled surveys, and minor actions to mitigate any identified deficiencies.

- The cap surrounding area will be visually inspected periodically. Visual inspections will be conducted to detect subsidence areas on the cap, erosion caused by wind and runoff, intrusion by plants, intrusion by rodents or other burrowing animals, or any other intrusion that may cause the cap to not perform in accordance with the design requirements. If the cap design includes seeding of specific types of vegetation, inspections will include a review of the vitality of the vegetation and intrusion by other vegetation.
- Controlled surveys of the cap and surrounding area will be conducted. Typically, design and construction of the cap requires installation of one or more controlled benchmarks to ensure the control of the extent and thickness of the cap can be established. The benchmarks will be maintained during post-closure and used to perform periodic controlled surveys. Survey data will be used to detect subsidence areas and placements of any new fill material.

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Table 8-1. INEEL land-use scenario summary.

Facility Area	Present	2019	2044	2069	2094
Test Area North (WAG 1)	Location of Specific Manufacturing Capability Program; industrial land use	Selection of facilities for D&D; industrial land use	Continuation of D&D; selected restricted industrial reuse	Development of non-nuclear DOE or non-DOE industrial facilities	Established industrial development area
Test Reactor Area (WAG 2)	Studying effects of radiation on material, fuels, and equipment; industrial land use	Continue operations; industrial land use	End of useful life if no new mission; D&D for restricted industrial use	Standby mode for restricted DOE or non-DOE industrial use; site constraints allow reuse, but no new development outside fence line	Continuation of restricted industrial use
Idaho Nuclear Technology and Engineering Center (WAG 3)	Interim storage of spent nuclear fuels; disposition of fuels; managing waste and improving waste and waste water management techniques; industrial land use	Continue use as industrial area; planned new waste treatment facility; closure of Tank Farm	Approaching end of useful life if no new mission; D&D with all or selected areas for restricted industrial use	Standby mode for restricted industrial use; reuse permitted, but no new development outside existing fence line	Continuation as a restricted industrial area
Central Facilities Area (WAG 4)	Technical and support service area for INEEL; industrial land use	New projects to support continual industrial/support activities	Continuation of support and service mission; industrial land use	Continuation of original mission; possible modification or new construction to support mission; industrial land use	Continuation of original mission; industrial land use

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Table 8-1. (continued).

Facility Area	Present	2019	2044	2069	2094
Waste Reduction Operations Complex/Power Burst Facility/Auxiliary Reactor Area (WAG 5)	Power Burst Facility: In standby mode pending D&D Waste Reduction Operations Complex: involved in low-level waste treatment; industrial land use Auxiliary Reactor Area: Phased out in 1965; support buildings are now vacant except for intermittent small-scale testing; industrial land use	Power Burst Facility: D&D reuse for industrial purposes; favorable site conditions; possibility for adaptive reuse; industrial land use Auxiliary Reactor Area: D&D; favorable site conditions; possibility for adaptive reuse; industrial land use	Power Burst Facility: Used for new DOE or non-DOE industrial use Auxiliary Reactor Area: Established "no new development" zone; use of existing developed areas; industrial land use	Power Burst Facility: Established industrial development area Auxiliary Reactor Area: Designated buffer zone; use of existing developed area; industrial land use	Power Burst Facility: Established industrial area Auxiliary Reactor Area: Buffer zone; use of existing developed areas; industrial land use
Experimental Breeder Reactor I/Boiling Water Reactor Experiment (WAG 6)	Experimental Breeder Reactor I: National Historic Landmark; recreational/industrial land use Boiling Water Reactor Experiment: D&D; restricted reuse; industrial land use	Experimental Breeder Reactor I: National Historic Landmark; recreational/industrial land use Boiling Water Reactor Experiment: Restricted use; industrial land use	Experimental Breeder Reactor I: National Historic Landmark; recreational/industrial land use Boiling Water Reactor Experiment: Restricted use; industrial land use	Experimental Breeder Reactor I: National Historic Landmark; recreational/industrial land use Boiling Water Reactor Experiment: Restricted use; industrial land use	Experimental Breeder Reactor I: National Historic Landmark; recreational/industrial land use Boiling Water Reactor Experiment: Restricted use; industrial land use
Radioactive Waste Management Complex (WAG 7)	Waste management support for various radioactive waste processing, storage, and disposal activities; industrial land use	Planned construction of waste management facilities; continue as industrial facility	Continue as an industrial waste management area	End of useful life; D&D to protective storage; industrial land use	Restricted use area for DOE or non-DOE industrial activities
Naval Reactors Facility (WAG 8)	Research and development facility for spent naval fuel and components; industrial land use	Continue operations of facilities; industrial land use	Continue operations of facilities; industrial land use	D&D; potential industrial reuse, but no new development	Continue as a restricted-use area; industrial land use

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Table 8-1. (continued).

Facility Area	Present	2019	2044	2069	2094
Argonne National Laboratory-West (WAG 9)	Spent nuclear fuel management and treatment research and development; Experimental Breeder Reactor II being decommissioned; industrial land use	Continue operations of facilities; industrial land use	Begin D&D process to dismantle for unrestricted use; industrial land use	Anticipated reuse as a DOE or non-DOE industrial use	Established area of new development; industrial land use
INEEL Sitewide (WAG 10)	Grazing buffer, restricted nesting, ecological research and environmental surveillance, habitat reference areas, borrow sources; agricultural/ recreational/industrial land use	No new major facility areas; other uses continue; agricultural/ recreational/industrial land use	New industrial corridor; transportation access; other uses continue; agricultural/ recreational/industrial land use	New industrial areas in central portion of INEEL; other uses continue; agricultural/ recreational/industrial land use	Selected D&D of facilities developed under 25-yr scenarios; other uses continue; agricultural/ recreational/industrial land use

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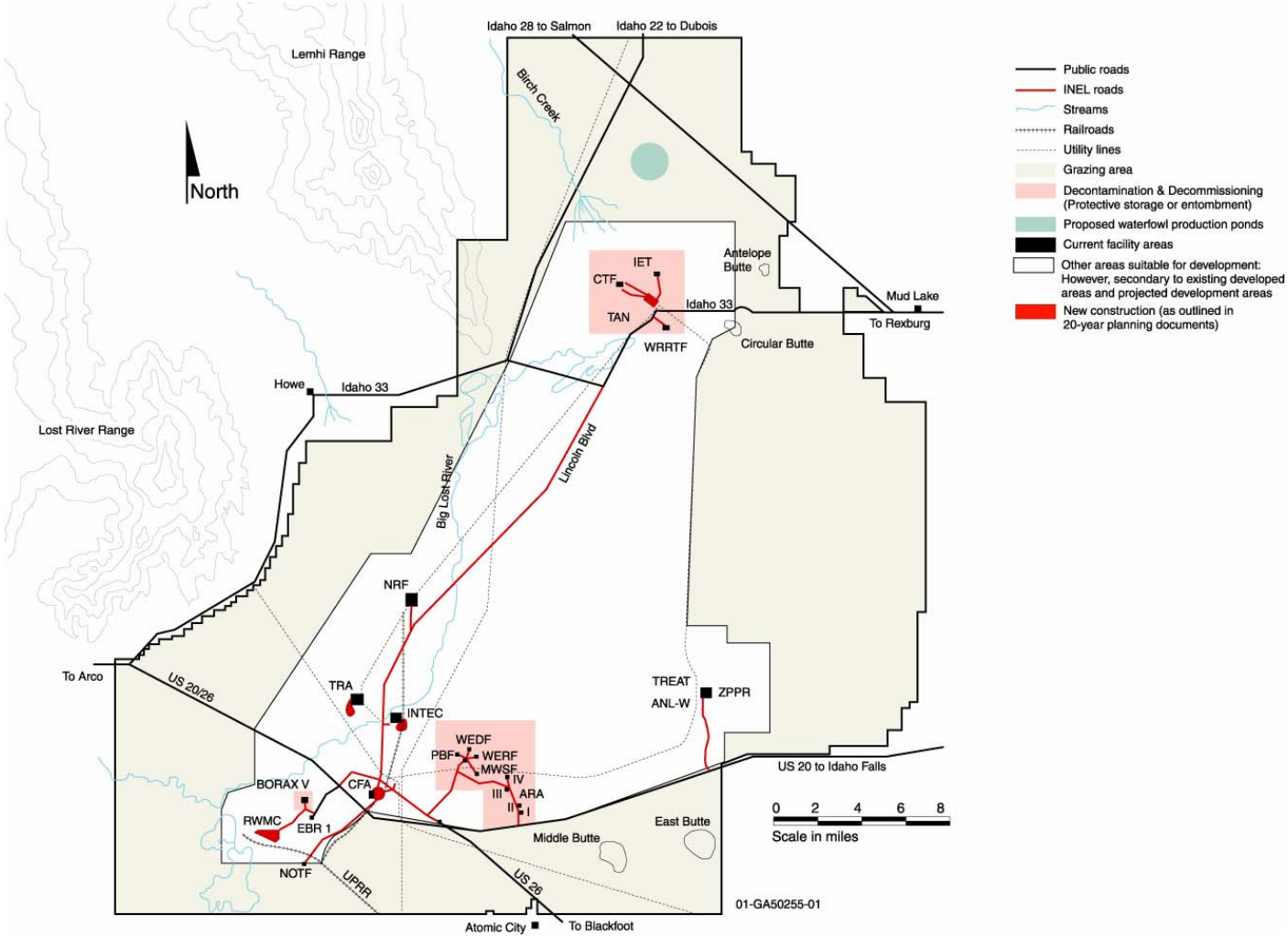

Figure 8-1. INEEL 25-yr land-use scenario (2019).

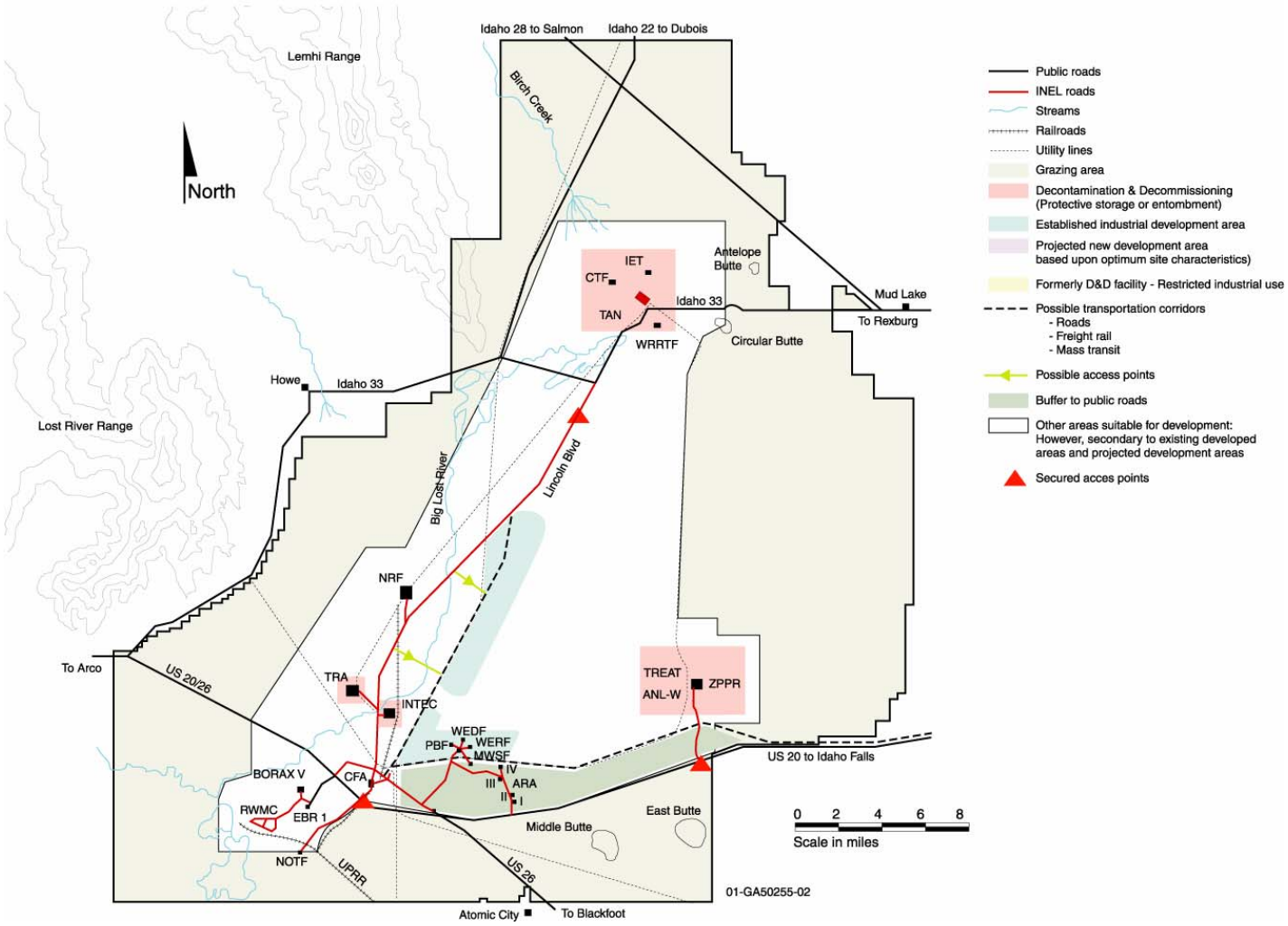

Figure 8-2. INEEL 50-yr land-use scenario (2044).

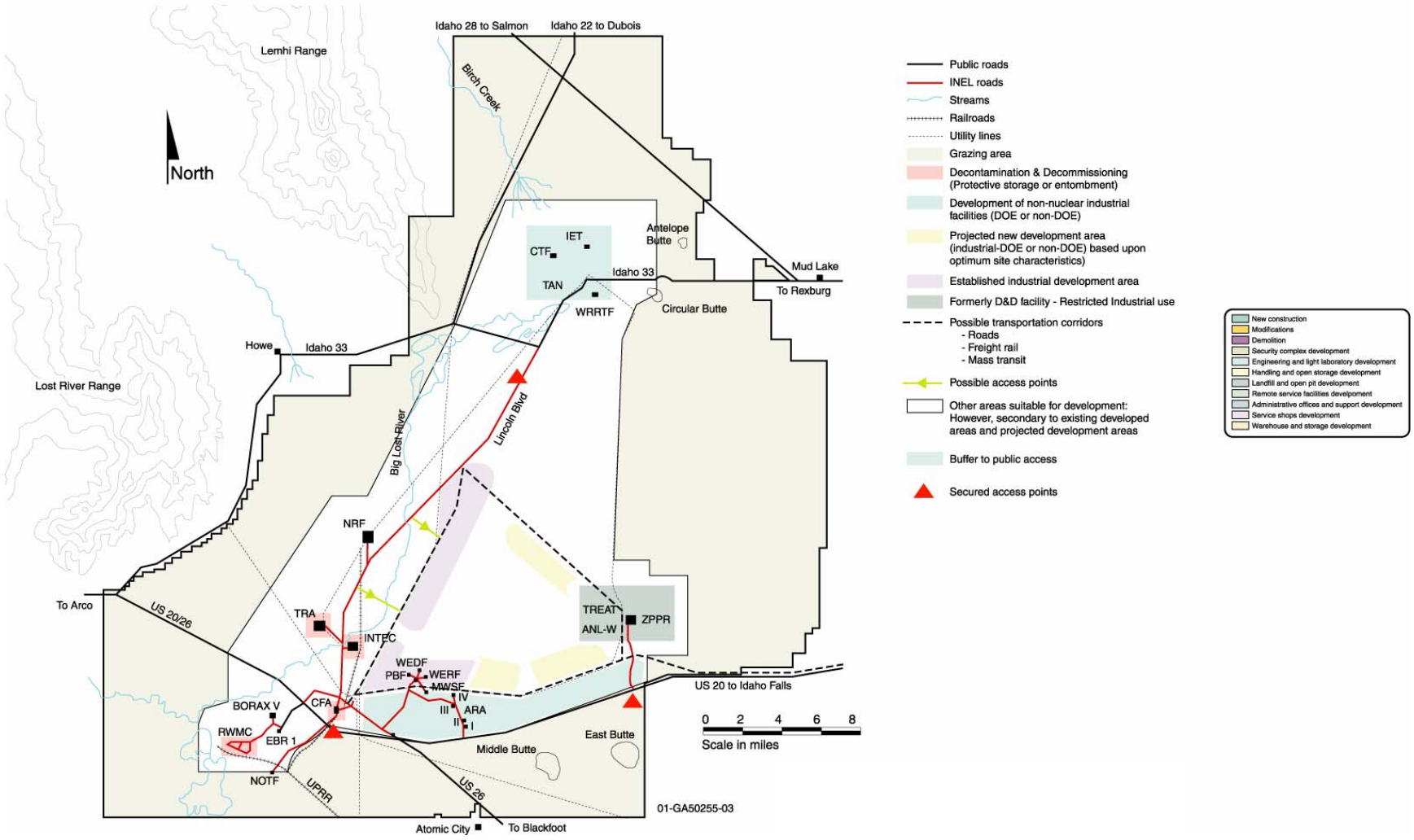

Figure 8-3. INEEL 75-yr land-use scenario (2069).

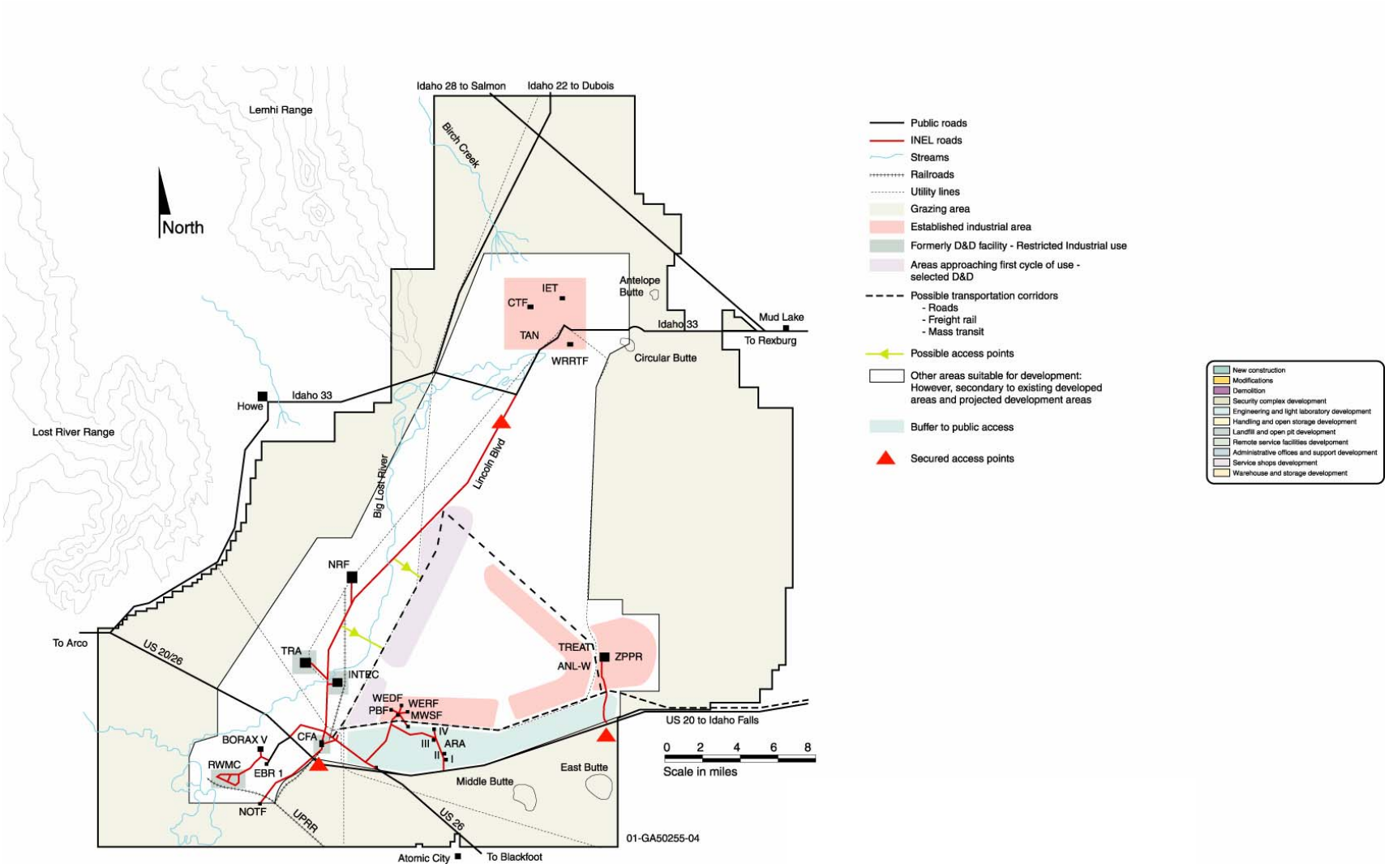

Figure 8-4. INEEL 100-yr land-use scenario (2094).

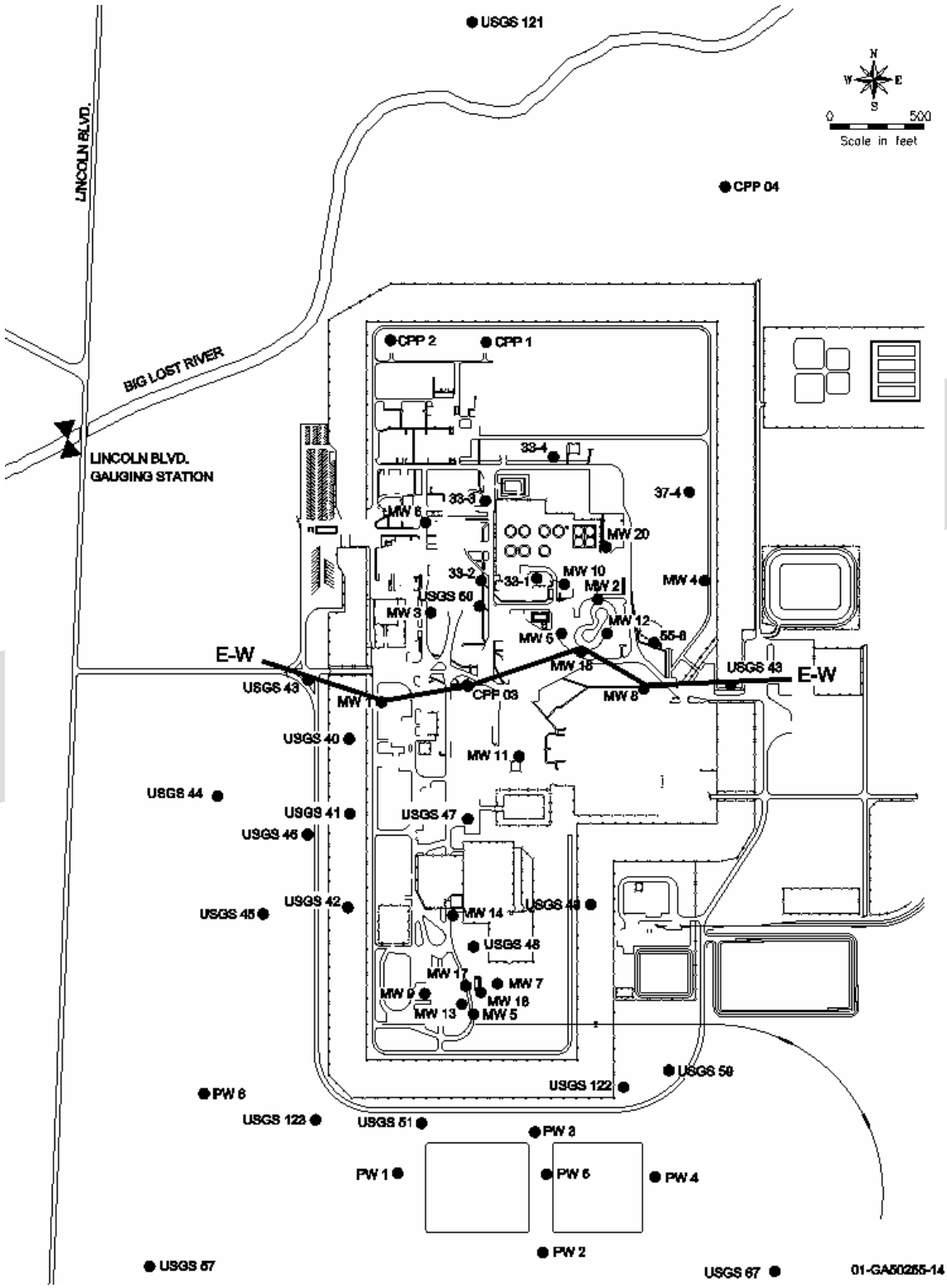

Figure 8-5. Existing monitoring well locations at INTEC.

- Vegetation will be seeded as necessary to protect against erosion by wind and runoff. Fences, gates, and signs will be inspected and maintained, as necessary, to ensure site control is maintained.

- Monitoring systems will be maintained. Groundwater monitoring wells and leak detection systems will be maintained to ensure the quality of periodic sampling data meets DQOs.

8.5 Access Controls

Access controls are currently implemented at the TFF through security restrictions at the INEEL main gates, the INTEC gate, and fencing around the TFF. Members of the public would be allowed into INTEC only for the purpose of public tours and only under restricted and supervised conditions. INEEL workers are allowed access to the TFF site only during approved work activities and under the conditions set forth in approved safety and radiological work permits. These controls will remain in place throughout the active life and closure phases of the TFF. After final closure, post-closure care will be implemented. During this period, DOE is assumed to maintain control of the INEEL and the INTEC facility. Access controls for the post-closure period will incorporate the following:

- Access by the public to the INTEC site and the TFF closure site will be controlled with the use of a buffer zone or industrial corridor

- Fencing the TFF closure site will inhibit access

- Signs, warning of the presence of the closed site, will be located strategically around the site, either on the fence or on sign posts.

8.5.1 Passive Controls

Passive controls include the use of

- Fencing to discourage access by humans and large animals

- Signs located on or near the fence designed to give information to workers and members of the general public indicating the nature of the closed facility

- Public warning monuments that indicate the presence of the closed TFF facility and the potential for exposure.

8.5.2 Restrictions

Restrictions to the closed TFF site are required by HWMA/RCRA during the certification of closure.

- A "Notice in Deed" will be prepared indicating that the land has been used to manage hazardous waste, land use is restricted, and the facility contractor's and DOE-ID's obligatory commitment to restrict disturbance of the closed unit

- A record of the type, location, and quantity of hazardous waste disposed of in the tank system components will be submitted to DEQ and the Butte County Commissioners.

8.5.3 Assumptions

Closure of the TFF will be completed by the year 2016, at which time an engineered cap will be placed over the site (OU 3-14) through CERCLA activities. Several critical assumptions, taken from the *Idaho National Engineering and Environmental Laboratory Comprehensive Facility and Land Use Plan* (DOE-ID 1997) used in the long-range plan, that impact the institutional controls at INTEC are presented below.

- Mission-end and end-state dates for INTEC are 2036 and 2050, respectively (DOE-ID 1997). These dates are critical elements of the plan and reflect the dates of the ER Program mission. The period between the mission-end and the end-state dates allows for the integration and completion of closure activities.

- Growth and new missions as presented in the *FY 2001-2005 INEEL Institutional Plan* (INEEL 2000c) have been projected in this

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plan. These elements also support DOE's strategic plan.

- All INEEL plans and associated documentation developed will use the assumptions identified in this document.

It should also be noted that ER site OU 3-14 includes the INTEC TFF soil surrounding the tanks and the groundwater beneath INTEC. Contaminated soil around the tank vaults and other contaminated soil areas at INTEC represent a contamination source to the perched water zones located relatively close to the ground surface. The perched water, in turn, represents both a contamination source and a transport mechanism to the SRPA. Additional water, primarily from the INTEC percolation ponds and the Big Lost River, also may transport contamination toward the aquifer.

8.5.3.1 Conceptual End State. Figure 8-6 shows a conceptual end state for INTEC. Because the end state of INTEC is dependent on the outcome of CERCLA actions, the actual end state may be different. This conceptual end state is consistent with current TFF closure planning. The end state includes four engineered caps over contaminated soil areas. The largest of these caps integrates the TFF closure project and the OU 3-13 TFF soils. The final remedy for the contaminated soil around the TFF will be included in the OU 3-13 ROD, scheduled for 2003, and the actual design will be performed in a remedial design work plan scheduled for the following year.

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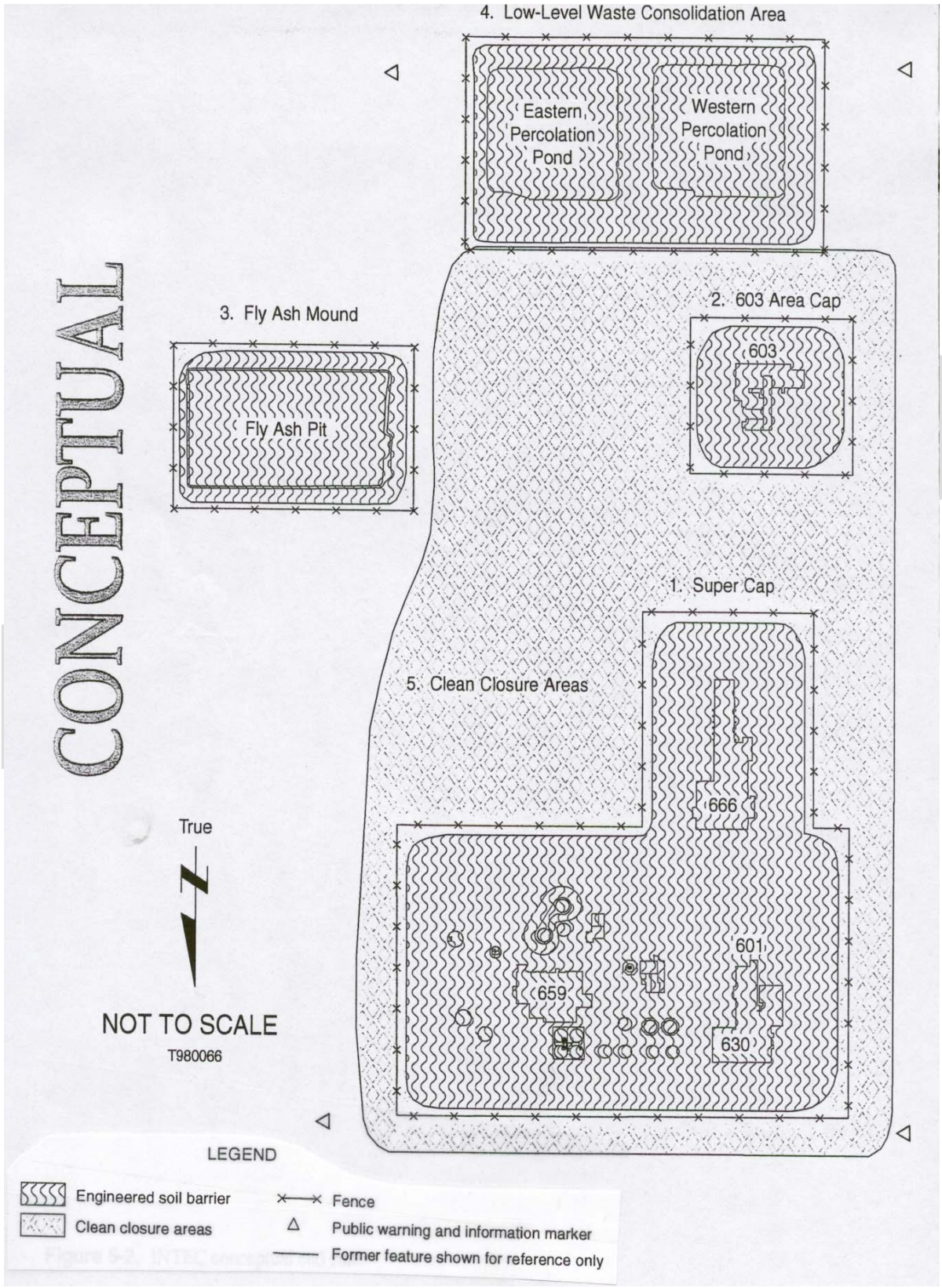

Figure 8-6. INTEC conceptual closure end state.

9. COGNIZANT ORGANIZATIONS

The primary cognizant organizations involved with closure of the TFF are identified below. The roles of each of these organizations, both internal and external to DOE, are described.

- DOE Office of Environmental Management (EM). As required by DOE Manual 435.1-1 (DOE 2001b), the Deputy Assistant Secretaries within the EM office are responsible for review and approval of the Tier 1 Closure Plan. The review is intended to reduce the risk of committing a significant amount of resources to a closure action before the Tier 1 Closure Plan has been approved by appropriate levels of management. A team of federal employees from DOE-Headquarters and field organizations are selected to ensure the process reflects the policy, technical, regulatory, and programmatic aspects necessary to conduct an effective review. The EM office will coordinate with DOE-ID on reviews of documentation related to closure of the TFF. The steering committee has issued the *Department of Energy Deactivated High-Level Waste Facility Closure Federal Review Group Manual and Tier 1 Closure Plan Content Guide* (DOE 2000a) as the primary guidance for this review. Once the Tier 1 Closure Plan is approved, the Deputy Assistant Secretary for EM will issue an Authorization to Proceed with closure activities.

- DOE-ID HLW Program. The mission of the HLW Program is strategic planning and program execution for the ultimate disposition of DOE radioactive liquid waste, high-level solid waste (calcine), contaminated mixed debris, and HEPA filters, according to legal and regulatory requirements. The primary scope and objectives of the program are the planning and execution of projects and technology development. These activities must comply with the *Site Treatment Plan* (INEEL 2001b), the 1992 Consent Order (IDHW 1992), and the *Idaho HLW and Facilities Final Disposition EIS* ROD. The program actively interfaces with other INEEL organizations and entities as required to develop technologies, processes, and facilities to meet required goals and milestones.

- DOE-ID ER Program. The ER Program investigates and performs cleanup of past releases at the INEEL under CERCLA. The ER Program is responsible for the CERCLA activities at INTEC under the INTEC Completion Project. An RI/FS for OU 3-14 TFF soils to investigate potential releases from the TFF are currently underway (DOE-ID 2000a). DOE is addressing past releases from the TFF as part of this investigation under CERCLA, as described in the FFA/CO (IDHW, EPA, and DOE-ID 1991).

- DEQ. DEQ oversees the implementation of the 1992 Consent Order (IDHW 1992) and the second modification to the Consent Order (IDHW 1998). DEQ is responsible for review and approval of the HWMA/RCRA Closure Plan (DOE-ID 2001a) submitted by DOE under the requirements of IDAPA 58.01.05.009 (2002) (40 CFR Part 265, 2002). The plan will be revised and updated as necessary until closure certification of the facility is provided to the DEQ Director. DEQ also has the responsibility to approve the permit to construct as required by the Clean Air Act.

- EPA. EPA will be involved in consultation with DOE on TSCA-related issues, as applicable.

- NRC. NRC may consult on closure methods and analyses in support of WIR determinations.

- U.S. Fish and Wildlife Service. The Fish and Wildlife Service must consider the actions presented in the *Idaho HLW and Facilities Disposition Final EIS* (DOE 2002) and decide whether or not these actions would likely create any adverse impact on threatened or endangered species or critical habitat under the Endangered Species Act (16 USC 1531 et

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seq., 1973). The Fish and Wildlife Service has made a preliminary determination that TFF closure actions would be unlikely to create adverse impacts for endangered species or critical habitats; therefore, further consultation with the Fish and Wildlife Service during this closure is expected to be minimal.

- INEEL HLW Program. The overall goals of the HLW Program are to meet the Consent Order requirements (IDHW 1992, 1998) by treating SBW and ceasing use of the five pillar-and-panel, 300,000-gal waste storage tanks by June 30, 2003. Cease use of the remaining six tanks will occur by December 31, 2012. HLW will be treated so it is ready for disposal and shipment out of Idaho by December 31, 2035. The program will continue management of liquid waste in the TFF and closure of the tanks.

- INEEL INTEC Operations. The operations organization is responsible for onsite support of closure activities. Operations will conduct closure deactivation steps and management of closure-generated wastes.

- INEEL Environmental Affairs. The Environmental Affairs organization ensures that the HWMA/RCRA closure plans and designs will result in closure actions compliant with environmental regulations. Environmental Affairs personnel assist in communications with DOE and DEQ on environmental regulatory issues. In concert with the TFF closure project, Environmental Affairs will develop stakeholder involvement opportunities.

- INTEC Completion Project. Completion of all Environmental Management activities at INTEC is under the responsibility of the INTEC Completion Project, a sub-project of the Idaho Completion Project. This project is responsible for all closure activities at INTEC, including the OU 3-14 soils and the TFF closure.

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10. FACILITY DISPOSITION ALTERNATIVES

Alternatives that would satisfy the requirements to manage HLW at INTEC were identified and evaluated in the *Idaho HLW and Facilities Disposition Final EIS* (DOE 2002). The EIS identified five waste processing alternatives and six facility disposal alternatives. The waste processing alternatives provide the means to retrieve, process, and dispose of mixed HLW and TRU waste.

10.1 Description

The facility disposition alternatives address the final risk component associated with disposition of INTEC HLW facilities. The facility disposition alternatives are

- No action
- Clean closure
- Performance-based closure
- Closure to landfill standards
- Performance-based closure with Class A grout disposal
- Performance-based closure with Class C grout disposal.

10.1.1 No-Action Alternative

Under the no-action alternative, the HLW facilities at INTEC would not be closed. Over the period of analysis from 2000 to 2035, many of the facilities could be deactivated. Surveillance and maintenance of HLW facilities would be routinely performed to ensure the safety and health of workers and the public until 2095. For purposes of analysis, it is assumed that institutional controls to protect human health and the environment would not be in effect after 2095.

10.1.1 Clean-Closure Alternative

Under this alternative, all the hazardous wastes and radiological contaminants, including contaminated equipment, would be removed from the facility or treated so the hazardous and radiological contaminants would be indistinguishable from background concentrations. Clean closure may require total dismantlement and removal of facilities. Use of the facilities after clean closure would present no risk to workers or the public from hazardous or radioactive constituents.

10.1.2 Performance-Based Closure Alternative

Under this alternative, closure methods would be determined on a case-by-case basis, depending on risk. For radiological and chemical hazards, performance-based closure would be in accordance with risk-based criteria. Most aboveground structures would be razed and most belowground structures would be decontaminated and left in place. Any remaining facilities would be decontaminated such that residual waste and contaminants would comply with applicable requirements to protect workers and the public. Post-closure monitoring might be required on a case-by-case basis.

10.1.3 Closure to Landfill Standards Alternative

Under this alternative, facilities would be closed in accordance with State of Idaho and federal requirements. Closure to landfill standards is intended to protect the health and safety of the workers and the public from release of contaminants from the facility. This could be accomplished by stabilizing waste residuals with grout, installing an engineered cap over the facility, establishing a groundwater monitoring system, and providing post-closure monitoring and care of the waste containment system, depending on the type of contaminants.

10.1.4 Performance-Based Closure with Class A Grout Disposal Alternative

This alternative would accommodate the potential use of the TFF and bin sets for disposal of the LLW fraction. The facility would be closed

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as described for the performance-based closure alternative. The TFF or bin sets would be used to dispose of LLW Class A grout.

10.1.5 Performance-Based Closure with Class C Grout Disposal Alternative

This alternative would also accommodate the potential use of the TFF and bin sets for disposal of the LLW fraction. The facility would be closed as described for the performance-based closure alternative. The TFF or bin sets would be used to dispose of LLW Class C grout.

10.2 Impacts of Alternatives

In addition to the facilities disposition (e.g., TFF closure) impacts discussed below, utilities and energy use impacts, and health and safety impacts can be found in the *Idaho HLW and Facilities Disposition Final EIS* (DOE 2002).

10.2.1 Impacts of Facility Disposition Alternatives

The facility disposition impacts section in the EIS evaluated the disposition of new and existing HLW facilities that would support the waste processing alternatives. The evaluation included the potential short- and long-term impacts for the new and existing HLW facilities, and the potential long-term impacts from the disposal of the grouted LLW fraction. Two types of facility disposition were evaluated in the EIS: disposition of new facilities under the five waste processing alternatives and disposition of the existing HLW facilities.

10.2.2 Land Use Impacts

The facility disposition alternatives could affect short- and intermediate-term impacts to land use within the confines of INTEC, although land-use outside of INTEC would not be affected. None of the facility disposition alternatives would require development of new facilities outside of the INTEC perimeter fence. Land currently committed to non-industrial use such as ecological research or permitted grazing would be converted to industrial use. Land use outside of the INEEL would also not be affected. Facility disposition activities would be consistent with the current and planned uses of INTEC (DOE-ID 1997).

10.2.3 Geology and Soils Impacts

Impacts to unique geologic features are not anticipated. All of the facility disposition alternatives would require additional soil for backfill and topsoil. Soil would be acquired from expanding existing soil pits on the INEEL. Additional soil would be required for the clean-closure and landfill closure alternatives for construction of an engineered cap.

10.2.4 Air Resources Impacts

Activities associated with the ultimate disposition of the HLW facilities would result in potential impacts on air resources in the INEEL region. Radionuclide emission levels from dispositioning of facilities would be much lower that those that would result from operating the facilities. The only exceptions to this would be those facilities that process or store waste in sealed form, such as packaging or interim storage facilities. The doses from these facilities would be extremely low and represent a small fraction of the natural background radiation and applicable standards. Nonradiological impacts are also minimal. When baseline levels are added to projected nonradiological impacts, criteria pollutant levels would remain well below applicable standards for all alternatives. Toxic air pollutant levels would also be well below reference levels for all alternatives.

For existing HLW facilities, the TFF, and the deactivated bin sets, the maximum annual and total emissions of radionuclides, criteria pollutants, toxic air pollutants, carbon dioxide, and fugitive dust were estimated. The concentrations of all radiological and nonradiological ambient air impacts are well below applicable standards.

10.2.5 Water Resource Impacts

Minimal short-term impacts to water resources would be caused by implementation of all the facility disposition alternatives except the

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no-action alternative. With the clean-closure alternative, no impacts are estimated because all contaminants would be removed and treated so that residual contamination is no higher than background levels. All remaining alternatives would leave residual contaminants at various concentrations, which would leach to the groundwater. Upon reaching the groundwater, the peak concentrations of contaminants would be less than groundwater standards and levels known to cause adverse health effects. The long-term impacts of leaving residual contaminants at the site were also evaluated. The EIS indicated that there were no instances where the peak groundwater concentrations would exceed the respective maximum contaminant level under the Clean Water Act.

10.2.6 Ecological Resource Impacts

Implementation of any of the facility disposition alternatives would have little or no impact on INEEL ecological resources. The ecological data collected over the past 25 yr provide a basis for analyzing environmental changes over time and assessing the effect of human influence on the environment. The short-term impacts of implementation of any the alternatives would be confined within the fenced perimeter of INTEC. None of these closure alternatives would require construction of new facilities outside the INTEC perimeter fence. Therefore, no loss or alteration of habitat would occur.

The long-term impacts on the ecology were evaluated from residual contamination in the soil or beneath an engineered barrier. The evaluation shows no long-term impacts to ecological resources within or near INTEC boundaries.

10.2.7 Environmental Justice

Executive Order 12898 (59 FR 7629, 1994), "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," directs each federal agency to

> *make…achieving environmental justice part of its mission*

and to identify and address

> *…disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.*

The *Idaho HLW and Facility Disposition Final EIS* (DOE 2002) is the means by which environmental justice requirements have been met for the TFF closure project. The approach used to assess potential environmental justice impacts during facility disposition was based primarily on Council on Environmental Quality guidance. Although no adverse impacts were predicted for the activities analyzed in the EIS, DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations as reported by the U.S. Bureau of the Census.

Relatively small numbers of workers would be required for facility disposition activities. DOE intends to retrain and reassign workers to conduct dispositioning activities to the extent practicable. Any socioeconomic impacts would be positive. None of the facility disposition alternatives is expected to significantly affect land use, cultural resources, or ecological resources because no previously-undisturbed onsite land would be required and no offsite lands are affected. DOE estimated emissions of radiological and nonradiological pollutants from dispositioning new and existing facilities required to support the various waste processing alternatives. These emissions would be temporary, lasting for a few (1 to 4) years following the shutdown of a facility. In general, radionuclide emission levels from dispositioning facilities would be lower than those resulting from operating the same facilities. In all cases, doses from dispositioning new facilities would be exceedingly low and make up a very small fraction of the natural background level. Criteria pollutant levels would remain well below applicable standards for all facility disposition

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alternatives. Toxic air pollutants would also be well below reference levels for all alternatives.

DOE also assessed the emissions from dispositioning existing facilities, including the TFF. In all cases, radiological doses from emissions would be low and nonradiological air impacts would be well below applicable standards. DOE assessed short- and long-term impacts to groundwater that may occur as a result of facility closure activities. Because facility disposition impacts would be small in all cases, there is no means for minority or low-income populations to be disproportionately affected.

10.2.8 Waste and Materials

The *Idaho HLW and Facility Disposition Final EIS* (DOE 2002) lists estimated volumes of waste generated during facility disposition activities. In accordance with IDAPA 58.01.05.005 (2002) (40 CFR 262, 2002), all solid waste generated during the TFF closure process is required to be properly characterized to determine whether or not the waste is a hazardous. If so, the waste must be managed as a hazardous waste in accordance with all applicable HWMA/RCRA regulations. Circumstances may arise during closure implementation that requires removal of equipment and treatment for reuse or disposal, rather than leaving the equipment in place as planned. Conversely, leaving some equipment in place may be necessary or desirable to limit personnel radiation exposure.

Wastes stored in the TFF exhibit the hazardous characteristics of corrosivity (hazardous waste number D002). Tank WM-182 exhibits the characteristic of toxicity for lead (D008) and mercury (D009) while WM-183 exhibits the toxicity characteristic for cadmium (D006), chromium (D007), lead (D008), and mercury (D009). Also associated with the waste are four RCRA-listed waste codes: F001, F002, F005, and U134 (Gilbert and Venneman 1999).

10.2.9 Decontamination and Treatment of Equipment for Disposal

Contaminated equipment from closure activities will be decontaminated or treated for all hazardous constituents present as indicated by the baseline sampling results and the historical inventory of wastes managed in the tanks. Treatment will consist of subjecting the equipment to one or more existing treatment technologies identified in IDAPA 58.01.05.011 (2002) (40 CFR 268, 2002). The specific technology or technologies will be selected at the time of closure based upon the contaminants subject to treatment, the effectiveness of the selected technology, and the ability of equipment to be effective in a highly radioactive environment. Equipment to be disposed of as solid waste will be disposed of in accordance with applicable local, state, and federal requirements. In some cases, the contaminated equipment may be dismantled, packaged, and transported to an onsite or offsite treatment, storage, and disposal facility.

10.2.10 Closure Waste

INTEC storage and treatment systems (e.g., PEW evaporator and TFF) may be used to store and treat wastes generated from the following sources:

- Valve box covers, valve boxes, and drain lines
- Vaults, vault sumps, and liquid removal lines to tanks and to the PEW evaporator
- Pipe encasements
- Condenser pit covers, pits, VOG, and VOG drain lines
- Purge liquids and decontamination solutions.

Alternatives for treatment and disposal methods for the liquid SBW and calcined wastes are addressed in the *Idaho HLW and Facilities Disposition Final EIS* (DOE 2002). If necessary, decontamination materials and residues (e.g., personal protective equipment, sampling equipment, and HEPA filters) will be placed in containers labeled with the date of accumulation and a barcode identifier, sampled and analyzed, and held within the TFF as mixed, low-level, or TRU waste as applicable. Based on process knowledge and the results of analysis, closure

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waste will be managed to ensure proper handling, treatment, storage, and disposal. Examples include, the following:

- HEPA filters determined to be waste or debris may be transferred to CPP-659 NWCF HEPA Filter Storage before treatment in the CPP-659 NWCF HEPA Filter Leach System and disposed of either onsite at RWMC or at an offsite facility. Debris treatment will be necessary before disposal at RWMC.

- Hazardous or mixed waste may be accumulated within the area of closure and either sent offsite for treatment and disposal or sent to CPP-1619, Hazardous Chemical and Radioactive Waste Storage Facility, before offsite shipment. If hazardous waste generated from the closure activity is maintained within the boundaries of the TFF closure, the 90-day storage limit will not apply, but all other handling, packaging, and inspection rules will apply.

- LLW can be sent to the Waste Reduction Operations Complex/Power Burst Facility for storage, volume reduction, and stabilization before disposal at RWMC. Mixed LLW may be managed similar to the LLW, except that disposal may include an offsite facility.

- If applicable, fluids from decontamination may be contained within a work/closure area or collected in containers until characterization results are obtained to ensure compliant storage and/or treatment and disposal.

10.3 Stakeholder Concerns and Issues

Two opportunities to collect stakeholder concerns and input have been conducted. This includes issuing the draft *Idaho Hazardous Waste Management/Resource Conservation and Recover Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183 Tank Systems* and the draft *Idaho HLW and Facilities Disposition EIS* for public comment.

10.3.1 Opportunities for Public Input on the HWMA/RCRA Closure Plan

The HWMA/RCRA closure plan was issued by the State of Idaho for review on March 15, 2002, for a 30-day review period. No comments were received on the plan.

10.3.2 Opportunities for Public Input on the HLW and Facilities Disposition EIS

In compliance with NEPA provisions (42 USC 4321–4347, 1969) and Council on Environmental Quality regulations (40 CFR 1503.1, 2002), DOE made the draft *Idaho HLW and Facilities Disposition EIS* available for public comment. The purpose of the draft EIS was to evaluate impacts to the environment from the various alternatives proposed.

DOE published the Notice of Availability of the EIS in the *Federal Register* (65 FR 14, 2000) on January 21, 2000, and subsequently extended the public comment period from 60 to 90 days in response to public requests (65 FR 37, 2000). The notice provided information on how the public could obtain copies of the EIS and the locations, dates, and times of the public hearings. Interested individuals could submit comments in writing by mail, fax, or electronic mail. In addition, they could also submit written or oral comments at public hearings held in Idaho Falls, Pocatello, Twin Falls, Boise, and Fort Hall, Idaho; Jackson, Wyoming; Portland, Oregon; and Pasco, Washington.

Table 10-1 shows the various means used to publicize the availability of the EIS and provide opportunities for the public to review and comment on the document. In addition to the public hearings, other activities included radio announcements in four western states, newspaper advertisements in nine states, distribution of Volumes 1 through 4 and information about the EIS to individuals and organizations in 27 states and the District of Columbia, and briefings for interested stakeholders. Briefings were held with government and tribal officials, public interest groups, INEEL employees, DOE citizens advisory

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Table 10-1. Draft EIS public involvement activities.

Activity	Date (2000 or otherwise stated)	Location (Idaho or otherwise stated)	Stakeholders (Total)
Public Hearings			
Idaho Falls	February 7	Shilo Inn	75
Pocatello	February 8	Idaho State University	16
Jackson Hole	February 9	Snow King Resort, Wyoming	103
Twin Falls	February 15	College of Southern Idaho	15
Boise	February 17	Doubletree Riverside	19
Portland	February 22	Doubletree Lloyd Center, Oregon	8
Pasco	February 24	Doubletree Pasco, Washington	20
Fort Hall	March 2	Tribal Business Center	22
Press Releases and Media Advisories			
Draft EIS availability, comment period	January 21	Regional media	NA[a]
Addition of the Fort Hall hearing	February 7	Regional media	NA
Portland and Pasco hearings	February 14	Portland, Oregon, and Pasco, Washington, media	NA
Extension of the public comment period	February 17	Regional media	NA
Close of the public comment period	April 13	Regional media	NA
Display Advertising Announcing Draft EIS Availability and Hearings			
Willamette Weekly	February 9	Willamette Valley, Oregon	NA
Oregonian	February 6	Portland, Oregon	NA
East Oregonian	February 5	Eastern Oregon	NA
Tri-City Herald	February 6	Eastern Washington	NA
Spokesman Review	February 6	Spokane, Washington	NA
Lewiston Morning Tribune	February 6	Lewiston, Idaho	NA
The Post Register	January 23 February 20	Idaho Falls, Idaho	NA
Teton Valley News	January 27	Driggs/Victor/Tetonia, Idaho	NA
Arco Advertiser	January 27	Arco, Idaho	NA
The Idaho State Journal	January 24 February 20	Pocatello, Idaho	NA
Jackson Hole News	January 26 February 23	Jackson, Wyoming	NA
Jackson Guide	January 26 February 23	Jackson, Wyoming	NA
West Yellowstone News	February 3	West Yellowstone, Montana	NA
Twin Falls Times News	January 31 February 20	Twin Falls, Idaho	NA

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Table 10-2. (continued).

Activity	Date (2000 or otherwise stated)	Location (Idaho or otherwise stated)	Stakeholders (Total)
Display Advertising Announcing Draft EIS Availability and Hearings (continued)			
Wood River Journal	February 2 February 23	Hailey/Ketchum/Sun Valley, Idaho	NA
Idaho Mountain Express	February 2	Hailey/Ketchum/Sun Valley, Idaho	NA
The Idaho Statesman	February 2	Boise, Idaho	NA
Sho-Ban News	February 24	Fort Hall, Idaho	NA
The Morning News	February 19	Blackfoot, Idaho	NA
Missoula Independent	January 27	Missoula, Montana	NA
Butte Weekly	January 26	Butte, Montana	NA
Argus Observer	February 6	Ontario, Oregon	NA
Salt Lake Tribune	January 30	Salt Lake City, Utah	NA
Wyoming Tribune Eagle	January 23	Cheyenne, Wyoming	NA
Daily Rocket	January 29	Rock Springs, Wyoming	NA
Laramie Boomerang	January 30	Laramie, Wyoming	NA
Denver Rocky Mountain News	January 30	Denver, Colorado	NA
Las Vegas Review Journal	January 30	Las Vegas, Nevada	NA
Carlsbad Current Argus	January 30	Carlsbad, New Mexico	NA
Albuquerque Journal	January 30	Albuquerque, New Mexico	NA
Radio Spots Announcing Public Hearings			
KLCE-FM/KOSZ-FM	February 4, February 5, February 7	Idaho Falls/Blackfoot/ Pocatello, Idaho, areas	NA
KID-AM/FM	February 4, February 5, February 7	Idaho Falls/Blackfoot/ Pocatello, Idaho, areas	NA
La Super Caliente/KID-AM/FM	February 5, February 6	Idaho Falls/Blackfoot/ Pocatello, Idaho, areas	NA
KECH/KSKI	February 12, February 14, February 15	Ketchum/Sun Valley/ Twin Falls, Idaho, areas	NA
KMTN/KSGT	February 7, February 8, February 9	Jackson, Wyoming, area	NA
KZJH	February 7, February 8, February 9	Jackson, Wyoming, area	NA
KUFO-FM	February 21, February 22	Portland, Oregon, area	NA
KONA-AM/FM/KXRX/KEYW	February 22, February 23, February 24	Richland/Tri-Cities, Washington, area	NA
KIDO	February 15, February 16, February 17	Boise, Idaho area	NA
Postcards			
To request copies of the Draft EIS	June 1999	Nationwide	6,144

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Table 10-2. (continued).

Activity	Date (2000 or otherwise stated)	Location (Idaho or otherwise stated)	Stakeholders (Total)
Toll-Free Line			
Information or document requests	January–November	Nationwide	89
Stakeholder Briefings			
Daryl Siemer	January 10	Idaho Falls	1
Stan Hobson	January 11	Idaho Falls	1
INEEL union representative	January 13	Idaho Falls	1
Wayne Pierre, Environmental Protection Agency	January 14	Teleconference	1
Jennifer Langston, Post Register	January 14	Idaho Falls	1
Idaho congressional staffs	January 18	Idaho Falls	6
Shoshone-Bannock Tribes	January 19	Fort Hall	14
Snake River Alliance	January 21	Pocatello	2
Wyoming congressional staffs	January 25	Jackson	4
Rep. Mike Simpson staff	January 26	Idaho Falls	4
INEEL Citizens Advisory Board	January 26	Boise	20
University of Idaho class	February 1	Idaho Falls	8
Idaho Nuclear Technology and Engineering Center employees open house	February 3	INEEL Site	88
Hanford Advisory Board subcommittee	February 3	Kennewick, Washington	6
Washington congressional staffs	February 3	Richland, Washington	6
Mayor Linda Milam	February 7	Idaho Falls	1
Jackson Hole Alternative High School	February 9	Jackson	20
Keep Yellowstone Nuclear Free	February 10	Jackson	4
Teton County Commissioners	February 10	Jackson	5
Coalition 21	February 11	Idaho Falls	16
Senator Larry Craig staff	February 25	Washington, DC	5
Distribution			
Summaries	January	NA	1971
Draft EIS (complete)	January	NA	897

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Table 10-2. (continued).

Activity	Date (2000 or otherwise stated)	Location (Idaho or otherwise stated)	Stakeholders (Total)
Citizens Advisory Board			
	March 1998	Idaho Falls	CAB[b]
	May 1998	Idaho Falls	CAB
	November 1998	Idaho Falls	CAB
	March 1999	Idaho Falls	CAB
	July 1999	Idaho Falls	CAB
	September 1999	Idaho Falls	CAB
	January 2000	Idaho Falls	CAB
	September 2000	Idaho Falls	CAB
	January 2001	Idaho Falls	CAB
	May 2001	Idaho Falls	CAB
	July 2001	Idaho Falls	CAB
	January 2002	Idaho Falls	CAB

a. NA = not applicable or not reportable in this format.

b. CAB = Citizens Advisory Board.

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boards in Idaho and Washington, and state and federal agencies.

10.3.3 Stakeholder Comment Summary

During the public comment period, approximately 100 individuals, agencies, and organizations provided over 1,000 comments. Frequently, similar or identical comments were submitted and in such cases, the comments were grouped and a single response was prepared for each group. Table 10-2 shows the various subject categories into which comments were grouped. Appendix C contains a listing of TTF-related comments and responses. DOE received comments from private citizens; businesses; local, state, and federal officials; Native American tribes; and public interest groups. Comments were received from stakeholders in Idaho, Wyoming, Washington, Oregon, Georgia, Nevada, Maryland, South Carolina, Wisconsin, and the District of Columbia.

Considerations of public comments on the draft EIS helped to ensure the adequacy of the EIS. From the public comments, the Final EIS incorporated enhancements as appropriate in response to the public comments and DOE and State of Idaho internal review. The specific changes noted in the EIS include the following

- Identified the DOE and State of Idaho preferred alternatives.
- Added "Other Information and Technologies Reviewed" (Chapter 2, Section 2.3.5). This new section summarizes DOE's review of information received from the National Academy of Sciences National Research Council commentors and others.
- Updated "Alternatives Eliminated from Detailed Analysis" (Chapter 3, Section 3.3) to clarify why some alternatives and technologies submitted in response to the Draft EIS discussion on purpose and need were not considered further by DOE.
- Modified data on transportation impacts for the Minimum INEEL Processing Alternative. Higher volumes of waste would be produced from vitrification of calcine at the Hanford Site than those analyzed for this alternative in the Draft EIS.

Table 10-2. Draft EIS public comment: number of comments per issue code in descending order.

Issue Code	Issue Title	Comments (Total)
II.E	Minimum INEEL Processing Alternative	81
III.C	Calcination	65
V	Waste Definitions, Characteristics, and Quantities	56
X	Costs, Funding, and Financial Considerations	54
XI	Issues Outside the Scope of the EIS	48
VII.D	Settlement Agreement	47
III.D.3	Separations Technologies	46
III.F.2	High-Level Waste Geologic Repository	40
VII.A	NEPA	38
IX.C	EIS Comment Period and Public Meetings	37
IX.D	Department of Energy Credibility and Suggested Forums for Resolution	37
IX.A	EIS - Overall Content, Format, and Appearance	36
III.D.2.b	Direct Cement Technology	34
II.A	General: Alternatives	33
III.D.1	General: Treatment Technologies	33
III.E	Storage of Treated Waste	32
VIII.B	Air Quality	31
VIII.C	Water Resources	30
III.D.2.c	Vitrification Technology	27
III.D.4	Treatment Technologies Considered but Eliminated from Further Consideration	24
VIII.A	General: Environmental Consequences	24
III.A	Storage: Liquid Sodium-Bearing Waste	22
VIII.G	Health and Safety	17
VI	Timing	12
VIII.H	Transportation	12
VII.B	Comprehensive Environmental Response, Compensation, and Liability Act	10
IV.C	Closure to Landfill Standards	9
VII.C	Resource Conservation and Recovery Act	7
VII.E	Tribal Issues	7
III.F.3	Transuranic Waste Isolation Pilot Plant	5
III.F.4	Low-Level Waste Near-Surface Landfill	5
IV.A	Clean Closure	5
IX.B	EIS Distribution	5
II.B	No Action Alternative	4
III.B	Storage: Calcine in Bin Sets	4
III.F.1	General: Disposal	4
I	Purpose and Need	3
II.D	Planning Basis Option	3
VIII.J	Utilities and Energy	3
II.C	Continued Current Operations Alternative	2
III.D.2.a	Hot Isostatic Press Technology	2
VIII.F	Land Use	2
IV.D	Performance-Based Closure with LLW Class A or Class C Grout	1
VIII.D	Biological Resources	1
VIII.E	Geology Seismic Risk	1
VIII.I	Socioeconomics	1

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- Updated the waste inventory information in Appendix C.7 of the EIS and made the corresponding changes in the long-term facility disposition modeling (Appendix C.9), facility accident analysis (Appendix C.4), and related sections.

- Expanded the discussion on the waste incidental to reprocessing procedure under DOE Order 435.1 and possible designation and disposal destination of wastes.

- Updated the "Affected Environment," Chapter of the EIS, so that the information is current.

The public comments and their resolutions had no significant impact on the TFF closure design.

10.3.4 Selection of a Preferred Alternative

The public comments and agency comments were considered in the selection of a preferred facilities disposition alternative. The evaluation of comments and DOE's response to each set of comments is presented in the Final EIS (DOE 2002). Based on the information presented in the draft EIS and the public comments, DOE and the State of Idaho have each selected their preferred alternatives. The State of Idaho preferred alternative is the direct vitrifrication alternative described in Section 3.1.6 of the EIS. This alternative includes the vitrification of mixed transuranic waste/SBW and vitrification of HLW calcine without or without separations.

The DOE preferred waste processing alternative is to implement a proposed alternative by selecting from among the action alternatives, options, and technologies analyzed in the EIS. Specifically, DOE's preferred alternative for waste processing is

- Select appropriate technologies and construct facilities necessary to prepare SBW for shipment to the Waste Isolation Pilot Plant

- Prepare the mixed HLW calcine so that it will be suitable for disposal in a repository

- Treat and dispose of associated radioactive waste

- Provide safe interim storage of HLW destined for a repository.

Both DOE and the State of Idaho have designated a performance-based closure method as the preferred alternative for disposition of HLW facilities at INTEC. These methods encompass three of the six facility disposition alternatives analyzed in the EIS: clean closure, performance-based closure, and closure to landfill standards. These methods are consistent with the closure approach proposed for the TFF in this closure document.

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11. CONCLUSIONS AND SUMMARY

This Tier 1 Closure Plan, along with the other TFF closure and support documentation (such as the HWMA/RCRA closure plan, the PA, the CA, and the WIR determination), represents the extensive research and planning effort for the TFF closure.

The TFF WIR determination process has demonstrated that the residual radioactive waste can be managed as LLW and that the TFF may be closed as a deactivated HLW facility.

The performance assessment for the TFF modeled current data to predict the performance of the closed TFF over a 1,000-yr period. Two hypothetical members of the public were modeled; one at the INEEL boundary during the institutional control period and one at INTEC during the post-institutional control period. The doses to these hypothetical persons were compared to performance objectives. The results noted in Table 11-1 indicate that the closure will meet the performance objectives.

The composite analysis identified all sources of radioactive material in the ground at the INEEL that could contribute to the potential doses from the TFF closure. Various INEEL areas and sources external to the closure site were identified and assessed for inclusion in the composite analysis. The projected dose from the sources of radioactive material is compared with the

The CA results indicate that the DOE primary dose limit of 100 mrem/yr and 30-mrem/yr dose constraint within a 1,000-yr period will not be exceeded. The maximum all-pathways dose to the INTEC receptor during the compliance period was found to be 2.8 mrem/yr at INTEC; the maximum all-pathways dose to the RWMC receptor from the INTEC source term was 1.8 mrem/yr during the compliance period. The analysis also showed that the combined dose from the sources included in the composite analysis and from doses at the Radioactive Waste Management Complex would be a maximum of 29.2 mrem/yr over a 1,000-yr period, which is less that the 30 mrem/yr dose guideline. All dose projections are less than the 100 mrem/yr limit

11.1 Conclusions

This Tier 1 Closure Plan for the INTEC TFF includes all of the elements required by DOE and demonstrates that long-term protection of the public and the environment from this closure is ensured. The analyses in the radiological performance assessment and the composite analysis supporting the Tier 1 Closure Plan are conservative and substantiated. The parameters as defined and bounded in this Tier 1 Closure Plan and supported by the performance assessment and composite analysis results provide strong evidence to support the approval of this plan and issuance of an *Authorization to Proceed*.

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Table 11-1. Comparison of the performance objectives and PA results.

Performance Objective	Performance Assessment Results[a]
All-Pathways 25 mrem/yr	1.86 mrem/yr
Airborne Emissions excluding radon 10 mrem/yr	0.51 mrem/yr
Average Annual Radon Flux 20 pCi/m^2/s	0.39 pCi/m^2/s
Protection of Groundwater 4 mrem/yr	0.77 mrem/yr
Acute Drilling Scenario 500 mrem/yr	232 mrem/yr at 100 yr
Chronic Post-Drilling Scenario 100 mrem/yr	91.1 mrem/yr at 100 yr

a. Source: DOE-ID 2003a.

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Appendix A

Review Criteria Matrix

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DOE Order 435.1 Review Criteria Matrix

DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 1.1 The Closure Plan describes the scope of the closure action being proposed. This scope includes a description of the facilities and/or sites that are included in the closure action, i.e., the boundaries, and a description of the closure activities that are to be taken.	**Scope of Closure Action** Section 2 presents the scope of the closure action **Description of Facilities** Section 2.2, Facility Description, describes the Tank Farm Facility (TFF) and its use. **Boundary** Section 2.4, Closure Boundary, defines the boundaries of the TFF closure action. **Closure Activities** Section 2.5, Closure Process, summarizes the overall closure sequence.
Criterion 1.2 The Closure Plan presents information on the following, sufficient to support the analysis in the Closure Plan: site geography, demography, land use plans, meteorology, ecology, geology, seismology, volcanology, surface water, and groundwater hydrology, geochemistry, geologic resources, water resources, and natural background radiation.	Appendix B of the Tier 1 Closure Plan and Section 2 of the Performance Assessment (PA) support the analysis for the areas described. **Site Geography** Section B-4.1.1, Area Description, presents the overall geographic features of the INEEL and southeast Idaho. **Demography** Section B-4.1.2, Demography, discusses population trends, land use of the INEEL, adjacent land use, and projected land use. **Land-Use Plans** Section B-4.1.2, Demography, refers to land-use planning. The primary discussion of land-use planning is in Section 8, Closure Control Planning. **Meteorology** Section B-4.2, Meteorology, presents a summary of temperature, wind, precipitation, evaporation, relative humidity, and severe weather. **Geology** The geology of the INEEL is discussed in Section B-4.4. Important aspects of the geology include subsurface stratigraphy that affects the movement of contaminants.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 1.2 (continued). The Closure Plan presents information on the following, sufficient to support the analysis in the Closure Plan: site geography, demography, land use plans, meteorology, ecology, geology, seismology, volcanology, surface water, and groundwater hydrology, geochemistry, geologic resources, water resources, and natural background radiation.	**Ecology** Section B-4.3, Ecology, summarizes important data related to flora and fauna. **Seismology** Section B-4.4.1, Seismology, presents a summary of earthquake data collected in the vicinity of the INEEL. **Volcanology** Section B-4.4.2, Vulcanology, includes a general discussion of the volcanic activity and basalt flows. **Surface Water** Section B-4.5.1, Hydrology, discusses the surface water features of the INEEL. **Groundwater Hydrology** An extensive discussion of groundwater hydrology is presented in Section B-4.5, Hydrology. **Geochemistry** Section B-4.6, Geochemistry, presents specific aspects of the soil, concrete, grout, and basalt. **Geologic Resources** Geologic resources are discussed in Section B-4.4.3, Geologic Resources. **Water Resources** Water resources are discussed in Section B-4.5, Hydrology. **Natural Background Radiation** Section B-4.4.4, Natural Background Radiation, discusses monitoring and assessment activities at the INEEL.
Criterion 1.3 The Plan identifies the applicable regulatory requirements, e.g., Federal, state and local statutes, regulations, agreements and permits, for the proposed closure action(s). This should include those required by DOE, e.g., DOE M 435.1-1, and interfaces with those required by other applicable regulations, e.g., RCRA.	**Federal/State Regulations, Permits, and Agreements** **DOE Manual 435.1** Requirements for DOE 435.1 are described throughout the document. Section 1 discusses the primary requirements for closure. Section 3, Integration with Other Regulatory Requirements, discusses requirements for closure.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 1.4 The Closure Plan identifies the procedures and facility or site related documentation, e.g., Facility Authorization Basis or Radioactive Waste Management Basis that may impact closure design and engineering and describes the impacts these procedures and documents may have on the proposed closure action(s).	**Facility or Site-Related Documentation** Section 3.8, Facility Documents that may Impact Closure, includes a description of the safety analysis overview.
Criterion 1.5 The Closure Plan describes the relationship of the proposed action, e.g., interim or operational closure, to the final closure of the facilities or sites, e.g., RCRA or CERCLA.	**Relationship of the Proposed Action…to the Final Closure of the Facilities** Section 3 discusses the integration of other programs with TFF final closure. Section 8, Closure Control Planning, presents current INEEL long-term planning and TFF closure.
Criterion 1.6 The Closure Plan identifies the primary cognizant organizations and their role(s) both within and outside DOE that are responsible for the proposed closure action(s).	**Primary Cognizant Organizations** Section 9, Cognizant Organizations, describes the organizations that are involved in the decision-making process for TFF closure. A brief summary is given of each organization and its role in the proposed closure action.
Criterion 2.1 The Closure Plan includes an overall schedule of the proposed closure action(s) for each facility or site. Identification of documentation development and approvals, other regulatory reviews and approvals, closure actions, and post-closure activities are also included.	**Overall Schedule of the Proposed Closure Action and Documentation Development and Approvals other Regulatory Reviews, and Closure Actions** Section 2.6 includes the project schedule for TFF closure. **Post-Closure Actions** Post-closure actions associated with the TFF are discussed in Section 8, Closure Control Planning.
Criterion 2.2 The Closure Plan identifies key prerequisites to be accomplished prior to initiation of closure activities, e.g., completion of deactivation activities.	**Key Prerequisites** Section 2.7, Schedule Prerequisites, includes key prerequisites that must be completed prior to initiation of TFF closure.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 2.3 The Closure Plan identifies and justifies the key assumptions included in the analysis that are critical to the conclusions of the Plan. Assumptions included are those that are related to the residual waste that is to remain in the closed facility or site and the design of the closure action(s).	**Key Assumptions** Section 1, Introduction, lists the key assumptions used in the analysis of closure.
Criterion 3.1 The Closure Plan identifies the radiological closure standards and performance measures, and a justification for their use to achieve the required level of protection of the public and the environment at the proposed closure facility or site.	**Radiological Closure Standards and Performance Measures** Section 4.1, Identification of Performance Objectives, identifies the radiological closure standards and performances measures and includes a justification for their use.
Criterion 4.1 The Closure Plan identifies the strategy or method for apportioning the identified radiological performance measures or closure standards to each of the facilities or units within the proposed closure action(s).	**Strategy or Method for Apportioning the Identified Radiological Performance Measures or Closure Standards** Section 5.5 discusses allocation of performance objectives.
Criterion 5.1 The Preliminary Composite Analysis identifies results, objectives, or milestones of other DOE Programs, Federal, state, or local statutes, or agreements [e.g., D&D, FUSRAP, CERCLA, and RODs] that may impact its analysis or conclusions.	**Other Programs** Section 1.3 of the Composite Analysis (CA) includes a discussion of the facilities evaluated. Section 3.1 of the CA includes a brief discussion of data collected by the INEEL ER Program at each of the potential release sites.
Criterion 5.2 The Preliminary Composite Analysis specifies and justifies the point of assessment for closure action(s) and all other contributing sources.	**Point of Assessment** Section 3 of the CA includes a description of INEEL facilities and associated radionuclide sources that could contribute to potential future doses.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.3 The Preliminary Composite Analysis identifies all sources of radioactive material in the ground that could contribute to the potential future doses from the closure action(s). Sources selected for the Preliminary Composite Analysis and the reasons for excluding any source are justified. Other potential sources of radioactive material to be considered include wastes disposed of prior to September 26, 1988, other LLW disposal facilities, transuranic waste or alpha LLW disposals, buildings, tanks, cribs, spills, ditches, seepage basins, and leaks. Sources selected should include those that could make a significant contribution to potential future doses associated with the closure facility or site.	**Potential Sources** Section 3 of the CA includes a discussion of the sources of radioactive material.
Criterion 5.5 The Preliminary Composite Analysis provides a technically justified methodology for estimating the release of radionuclides from the contributing sources to the closure action selected for the Preliminary Composite Analysis.	**Methodology for Release of Radionuclides** Section 3.1 of the CA presents the sources included in the groundwater pathway analysis. The justification for each source is provided in these sections.
Criterion 5.6 The Preliminary Composite Analysis presents a technically justified methodology for estimating the transport of radionuclides to the point of assessment from sources external to the closure action, based on the available data for characterizing environmental behavior.	**Methodology for Transport of Radionuclides** Section 4 of the CA includes a brief discussion of the data used for each radiological source and modeling for contaminant release.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.7 The Preliminary Composite Analysis provides a discussion for all important exposure pathways for the evaluation of potential doses to a hypothetical, individual member of the public at the point of exposure for any time during the period of assessment. The exposure pathways identified in the Preliminary Composite Analysis should be consistent with the exposure pathways in the Preliminary Assessment for each facility or site. The exposure pathways considered in the Preliminary Composite Analysis include only those pathways that are related to the exposure of individual members of the public at the point of assessment and are justified.	**Exposure Pathways** A discussion of important exposure pathways is included in Section 4.1 of the CA.
Criterion 5.8 The Preliminary Composite Analysis provides a coherent presentation of the relevant descriptive information concerning the closure facility or site, its location on the DOE site, and its proximity to other sources of radioactive material. The sources of radioactive material are described along with the methodology for assessing the migration of radionuclides to the point of assessment, and the exposure scenarios following transport.	**Closure Facility Information** Section 3 of the CA describes INEEL facilities and associated radionuclide source terms and migration of contaminants.
Criterion 5.9 The Preliminary Composite Analysis presents an assessment using the time of 1,000 years for exposures to hypothetical members of the public with all disposal facilities closed, decontamination and decommissioning completed, and operations at the DOE site terminated. The assessment establishes a "base case," that is a reasonably conservative, but realistic case for the comparison with the dose limit and dose constraint.	**Assessment Period** Sections 1.2.4 and 1.5 of the CA define the assessment performance period at 1,000 yr.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.10 The calculated results presented in the Preliminary Composite Analysis are consistent with the site characteristics, waste characteristics, and conceptual model of the DOE site. The calculated results bound the available site monitoring data and any other data from supporting field investigations.	**Calculated Results** The CA results are presented in Section 6 of the CA.
Criterion 5.11 The sensitivity or uncertainty of the results is analyzed, including the consideration of alternative land uses and remedial actions. Uncertainties in radionuclide inventories for the closure facility or site or other contributing sources are analyzed.	**Sensitivity, Uncertainty Analysis** Section 5 of the CA provides a sensitivity and uncertainty analysis for the models and assumptions upon which it was based.
Criterion 5.12 The calculated results and the sensitivity or uncertainty analysis results are interpreted to evaluate meeting the DOE Order 5400.5 administratively limited dose constraint of 30 mrem/year and the dose limit of 100 mrem/year at the point	**Sensitivity, Uncertainty Analysis** Section 5 of the CA provides the sensitivity and uncertainty analysis.
Criterion 5.13 An options analysis is performed that identifies alternative actions, which could be performed to reduce potential doses to a member of the public for results, which exceed the dose constraint, if applicable. The options analysis also identifies alternative actions which could be performed to reduce potential does to a member of the public for results that exceed the dose limit.	**Options Analysis** Section 6.1 of the CA addresses the options analysis.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.14 Credits for CERCLA actions or other remedial actions are represented in the conceptual models used in the Preliminary Composite Analysis, and are justified by supporting or referenced information.	**Credit for CERCLA and other Remedial Actions** Section 3 of the CA includes CERCLA actions as part of the same term as used in the analysis.
Criterion 5.15 Source terms and flow and transport models in the Preliminary Composite Analysis are commensurate the available data, incorporate the important characteristics identified in the Preliminary Assessments, and provide results consistent with individual facility Preliminary Assessments.	**Source Terms** Section 1.6.1 of the CA provides general information on the source terms. Section 1.3 discusses each facility source term used in the analysis. **Results** Section 6 of the CA compares the modeling activities of the CA with the modeling results from other INEEL facilities.
Criterion 5.16 The assumptions in the Preliminary Composite Analysis are justified for the radionuclides to be considered, the inventories of radionuclides, the source term evaluation, and the transport of radionuclides.	**Assumptions** The general modeling assumptions are discussed in Section 4.4 of the CA.
Criterion 5.17 Any mathematical models proposed or used in the Preliminary Composite Analysis for transport of radionuclides to the point of assessment are appropriate for the closure facility or site and all other contributing sources. The mathematical models used in the Preliminary Composite Analysis provide calculated results that are consistent with the roll-up results representative of the results calculated in the Preliminary Assessments.	**Sensitivity, Uncertainty Analysis** Section 5 of the CA discusses the sensitivity and uncertainty analysis.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.18 The sensitivity or uncertainty analysis considers factors such as alternative land use plans, remedial actions, radionuclide inventories, site and facility characteristics, and transport parameters to provide reasonable estimates of potential doses at the point of assessment for the period of assessment. The maximum projected dose over the period of the assessment (at least 1,000 years) is presented at the point of assessment.	**Factors Considered** Section 5 of the CA discusses the sensitivity and uncertainty analysis and factors considered therein.
Criterion 5.19 The need for an ALARA assessment as well as the ALARA assessment itself is demonstrated using a cost-benefit analysis based on the cost of dose-reduction in the exposed population of $1,000 to $10,000 per person-rem averted. ALARA assessments are not required if the projected individual or collective doses in the exposed population are trivial.	**ALARA Assessment** The qualitative ALARA assessment, Section 4.6.6 of the Tier 1 Closure Plan, was performed for the proposed TFF closure. The cost versus benefits of dose reduction will be evaluated as cleaning and sampling data become available.
Criterion 5.20 The options analysis considers alternatives, which are technically feasible and demonstrated to be effective in reducing doses to the public at the point of assessment over the period of assessment.	**Options Analysis** Section 6.1 of the CA addresses the options analysis.
Criterion 5.21 The results of the analysis for the source terms and transport of radionuclides, dose analysis, sensitivity or uncertainty analysis, and options analysis are reasonable representations of the existing knowledge of the site, closure facility or site, and contributing sources.	**Results** Section 6 of the CA presents the performance evaluation, which includes the analysis results.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 5.22 The conclusions of the Preliminary Composite Analysis are derived from the interpretation of the calculated results for the closure facility or site and all contributing sources and the sensitivity or uncertainty analysis, and lead to the development of an options analysis if required.	**Conclusions** Section 6 of the CA presents the performance evaluation, which includes the analysis results.
Criterion 5.23 The conclusions of the Preliminary Composite Analysis, presented in the interpretation of results and options analysis, can be reasonably accomplished at the closure facility or site implemented to affect the radionuclide contribution to dose from the other contributing sources.	**Conclusions** Section 6 of the CA presents the performance evaluation, which includes the analysis results.
Criterion 5.24 The conclusions of the Preliminary Composite Analysis addresses and incorporate constraints resulting from other DOE programs or from Federal, state, and local statutes or regulations, or agreements that would influence the calculated results or the options analysis.	**Conclusions** Section 6 of the CA presents the performance evaluation, which includes the analysis results.
Criterion 5.25 The analysis results, and conclusions of the Preliminary Composite Analysis provide a reasonable representation of the closure facility or site and other contributing sources for determining the appropriate actions to be taken for the protection of public health and environment.	**Results and Conclusions** Section 6 of the CA presents the performance evaluation, which includes the analysis results.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 6.1 The Preliminary Assessment presents information on the closure design features that address water infiltration, disposal unit cover integrity, structural stability, and the inadvertent intruder barrier sufficient to support the analysis presented in the Preliminary Assessment.	**Closure Design Features** Water infiltration was incorporated in the modeling as discussed in Section 3 of the PA.
Criterion 6.2 The Preliminary Assessment identifies procedures and facility related documentation (e.g., Safety Analysis Report, Operational Readiness Review, Waste Acceptance Criteria) that may impact site engineering, facility design, or facility operations. The Preliminary Assessment also describes the impacts of these procedures and documents based on the results of the analyses.	**Facility Related Documentation** Section 1.3 of the PA summarizes the facility documentation for the TFF.
Criterion 6.3 The Preliminary Assessment identifies the point of assessment for each performance measure, and briefly discusses the basis for its selection. The point of assessment is where compliance with the performance measures is evaluated.	**Point of Assessment** Section 1.4 of the PA identifies the points of assessment for the pathways discussed in this section.
Criterion 6.4 The Preliminary Assessment describes the projected radionuclide inventory in the residual waste present in the closure facility or site that could significantly contribute to dose for the all pathways analysis, the air pathway analysis, the groundwater analysis, and the intruder analysis. Technical justification is provided for those radionuclides present but not considered in detail in the analyses.	**Projected Radionuclide Inventory** Section 3 of the PA summarizes the projected residual waste inventory and justification for use.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 6.5 The Preliminary Assessment identifies the mathematical models used in the analysis, the basis for their selection, and their linkage.	**Mathematical Models** Section 3.3 of the PA describes the models used for source term, groundwater flow and transport, radon transport, volatile radionuclide, and the all-pathways dose.
Criterion 6.6 The Preliminary Assessment provides a general description of the important exposure pathways and scenarios in the evaluation of the potential doses to a hypothetical, individual member of the public and inadvertent intruder, consistent with site-specific environmental conditions and local and regional practices. These exposure pathways and scenarios are justified as conservative representations of the long-term performance of each closed facility or site.	**Important Exposure Pathways and Scenarios** Section 3.2 summarizes the pathway selection process. Also included are the time periods of concern for institutional control and post-institutional control periods.
Criterion 6.7 The preliminary calculated results presented in the Preliminary Assessment adequately bound the available site monitoring data and supporting field investigations as a benchmark of model adequacy.	**Calculated Results…Adequately Bound the Available Site Monitoring Data** Section 6 summarizes the results of the PA, which are based on available site data.
Criterion 6.8 The Preliminary Assessment includes a comparison to the performance measures used, and includes any necessary limitations on individual facility design, inventories, or closure operations that are required to meet the performance measures.	**Comparison to Performance Measures** Section 7.1 of the PA provides a comparison of the results of the PA with the performance objectives.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 6.9 The conceptual model for the source term, groundwater flow, and radionuclide transport includes parameters for unsaturated and saturated flow, total and effective porosity, hydraulic conductivity, water retention, relative permeability relationships, volumetric water content, retardation, and diffusion that are based on data, related investigations, or documented references relevant to each facility. This may be done collectively within the Preliminary Composite Analyses if these characteristics can be justified to be similar throughout.	**Conceptual Model for the Source Term, Groundwater Flow, and Radionuclide Transport** Section 6 in the PA presents a summary of the mathematical models and conceptual models used. The source term modeling of release rates from the vaults and tanks was conducted with the DUST-MS computer code. Groundwater transport modeling was accomplished for the PA (and the CA) with PORFLOW, a comprehensive mathematical model for the simulation of multiphase fluid flow, heat transfer, and mass transport processes in variably saturated porous and fractured media. Radon was modeled using a one-dimensional, diffusion only model for transport of radon to the surface of the facility.
Criterion 6.10 The dose analysis considers the exposure pathways and transfer factors and calculates the maximum dose using acceptable methodologies and parameters.	**Dose Analysis** The exposure pathways are discussed in Section 3.2 of the PA. The PA contains a detailed discussion of the transfer factors, methodologies and parameters.
Criterion 6.11 The inadvertent intruder analysis considers the natural and man-made processes that impact the possible exposure to an intruder and calculates the dose using acceptable methodologies and parameters.	**Inadvertent Intruder Analysis** Section 5 of the PA describes the processes that may cause potential dose to an inadvertent intruder. Calculations of dose and the methodologies and parameters may be found in the PA.
Criterion 6.12 The results of the analyses for transport of radionuclides and the inadvertent intrusion into the closure facility or site, and the sensitivity and uncertainty of the calculated results are comprehensive representations of the existing knowledge of the site and the closure facility or site design and operations.	**Results of the Analyses for Transport of Radionuclides and the Inadvertent Intrusion into the Closure Facility** Section 5 of the PA describes the Inadvertent Intruder Analyses.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 6.13 The Preliminary Assessment presents valid conclusions that demonstrate the all-pathways analysis, air pathway analysis, groundwater resource protection analysis, and inadvertent intruder analysis meet the performance objectives or measures of DOE M 435.1-1.	**Conclusions** The conclusions in Sections 6 and 7 of the PA demonstrate that the performance objectives for the all-pathways, air pathway, and inadvertent intruder analysis are met.
Criterion 6.14 The Preliminary Assessment conclusions incorporate the findings of the calculated results for the all pathways analysis, air pathway analysis, groundwater resource protection analysis, inadvertent intruder analysis, and sensitivity and uncertainty analysis. The results are interpreted and integrated to formulate conclusions, which are supported by the results and the uncertainties in the results.	**Calculated Results** Sections 6 and 7 of the PA summarize the calculated results of all pathways evaluated.
Criterion 6.15 The conclusions of the Preliminary Assessment are applied to the proposed closure action design. The resulting design constraints and limitations on closure operations can be reasonably accomplished at the closure facility or site.	**Conclusions** The conservative analysis in Sections 6 and 7 of the PA demonstrate that the proposed closure action can be performed within the required objectives.
Criterion 6.16 The Preliminary Assessment conclusions are within the budget allocated to the closed facility or site for performance relative to each pathway. Rationale is provided to justify the adequacy of individual facilities that do not agree with budgeted performance objectives.	**Conclusions** The results are included in Section 6 of the CA.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 6.17 The results of the Preliminary Composite Analysis options analysis are reflected, as appropriate, in the Preliminary Assessment of the individual facility or site(s).	**Options Analysis** Section 6.1 of the CA addresses options analysis.
Criterion 6.18 The analysis, results, and conclusions of the Preliminary Assessment provide both a reasonable representation of the closure facility's or site's long-term performance and a reasonable expectation that the closure facility or site will remain in compliance with DOE M 435.1-1.	**Long-Term Performance** The long-term performance of the proposed TFF closure is defined by the PA in Sections 6 and 7. The analysis is sufficiently conservative to ensure that the TFF will remain in compliance with DOE M 435.1-1.
Criterion 7.1 The alternative methods for removing the HLW from the proposed closure facilities or sites reviewed as part of the proposed closure action(s) are identified and discussed.	**Alternative Methods** Section 7 of the Tier 1 Closure Plan, Alternatives, presents the engineering alternatives evaluated for removal of waste from the TFF. The overall HLW facility disposition alternatives were taken from the draft Environmental Impact Statement, discussed in Section 10 of the Tier 1 Closure Plan.
Criterion 7.2 The closure configuration alternatives analyzed for the proposed closure action(s) are included and discussed in sufficient detail.	**Configuration Alternatives** The configuration alternatives are presented in Section 7 of the Tier 1 Closure Plan. Additional waste removal techniques were studied as part of the conceptual design process through conduct of full-scale waste removal and residual solidification mock-up tests. The results of these were incorporated in the conceptual design and process description.
Criterion 8.1 The physical, chemical, and radiological characteristics of the residual waste are sufficiently identified, using either direct or indirect methods, and documented in a manner that supports the proposed closure action(s).	**Characteristics of the Residual Waste** In the Tier 1 Closure Plan, Section 2.3 presents the waste generated from INTEC operations and Section 4.3 summarizes the data used to develop the inventory and the assumptions used to estimate the inventory are also presented. Section 6 presents the proposed closure sampling activities. The data quality objectives in for the proposed sampling and analysis activities are based on the most current analytical data.

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DOE O 435.1 Review Criteria Matrix

Review Criteria	Document Section and Comments
Criterion 8.2 The data quality process, or a comparable process, was used for identifying the characterization parameters and acceptable uncertainty in the characterization data.	**Data Quality Process** Section 6 of the Tier 1 Closure Plan presents the proposed closure sampling activities. The data quality objectives in for the proposed sampling and analysis activities are based on the most current analytical data.
Criterion 9.1 The Closure Plan identifies which monitoring activities may be required after the closure actions(s) is completed. This may include monitoring wells, data to be collected, and actions required in response to monitoring results.	**Monitoring Activities** Section 8, Closure Control Planning, of the Tier 1 Closure Plan addresses the current INTEC monitoring programs.
Criterion 9.2 Closure site institutional control measures are described. These may include custodial maintenance, access controls, corrective actions, passive controls and restrictions, reporting requirements, and record keeping.	**Institutional Control Measures** In the Tier 1 Closure Plan, Section 8, Closure Control Planning, summarizes the current status of institutional control measures possible for the TFF. This includes a discussion of the access controls such as fences, signs, public warning monuments, and restrictions. Planning processes for institutional controls have been implemented to update the current status of controls and other features and closures are completed.
Criterion 9.3 Institutional control measures are integrated into the site's land use and stewardship plans and programs to ensure that control of the closure site is not compromised.	**Institutional Control Measures** Section 8, Closure Control Planning, of the Tier 1 Closure Plan describes the current project status of planned TFF institutional controls, which are based on current land use planning. This section summarizes current land use planning documents, closure monitoring, and critical assumptions. A significant level of planning has been performed at the INEEL to attempt to predict future land uses based on reasonable scenarios and integrate programmatic goals.
Criterion 10.1 Stakeholder concerns and issues with the proposed closure action(s) are identified and addressed to the extent possible.	**Stakeholder Concerns and Issues** In the Tier 1 Closure Plan, Section 10, Stakeholder Concerns and Issues, summarizes the current progress of public involvement and comment on the HLW Environmental Impact Statement.

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Appendix B

Site Background

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Appendix B

Site Background

This section provides descriptive information and data on the Idaho National Engineering and Environmental Laboratory (INEEL) site and was the basis for the Tank Farm Facility (TFF) conceptual model used in the performance assessment (PA) and composite analysis (CA). This section presents the geography (site geography, demography, use plans), meteorology, ecology, geology (seismology, volcanology, geologic resources, and natural background radiation), hydrology (surface water, groundwater, and water resources), and geochemistry of the INEEL and, where applicable, areas in the vicinity of Idaho Nuclear Technology and Engineering Center (INTEC). The emphasis of this information is on the characteristics that are important to the performance of the TFF closure action. Topics presented in this section are summarized and are supported by more detailed discussions in the *Performance Assessment for the Tank Farm Facility at the Idaho Nuclear Technology and Engineering Center* (DOE-ID 2001).

B-1. SITE GEOGRAPHY

B-1.1 Area Description

The INEEL is located in the Mud Lake–Lost River Basin (also known as the Pioneer Basin). This closed drainage basin includes three main streams–the Big and Little Lost Rivers and Birch Creek. These three streams drain the mountain areas to the north and west of INEEL, although most flow is diverted for irrigation in the summer months before it reaches the site boundaries. Flow that reaches INEEL infiltrates the ground surface along the length of the stream beds, in the spreading areas at the southern end of the INEEL, and, if the stream flow is sufficient, in the ponding areas (playas or sinks) in the northern portion of the INEEL. During dry years, there is little to no surface water flow on the INEEL. Because the Mud Lake–Lost River Basin is a closed drainage basin, water either infiltrates the ground surface to recharge the aquifer or is lost to evapotranspiration.

The Big Lost River flows southeast from Mackay Dam, past Arco, and onto the Snake River Plain. Near the southwestern boundary of the INEEL, a diversion dam prevents flooding of downstream areas during periods of heavy runoff by diverting water to a series of natural depressions or spreading areas (DOE 1995). During periods of high flow or low irrigation demand, flow in the Big Lost River continues northeastward past the diversion dam, passes within 200 ft (61 m)[a] of the INTEC. It ends in a series of playas 15 to 20 mi (24 to 32 km) northeast of INTEC, where water infiltrates the ground surface. Flow from Birch Creek and the Little Lost River infrequently reaches the INEEL, as this water is diverted in summer months for irrigation prior to reaching the INEEL. During periods of unusually high precipitation or rapid snow melt, water from Birch Creek and the Little Lost River may enter INEEL from the northwest and infiltrate the ground.

The principal surface materials at the INEEL are basalt, alluvium, lake bed or lacustrine sediments, slope wash sediments, talus, silicic volcanic rocks, and sedimentary rocks. The natural plant life consists mainly of sagebrush and various grasses. The vegetation of the INEEL is limited by soil type, meager rainfall, and extended drought periods. Only a few deciduous trees, located principally along the Big Lost River, exist on the INEEL. The most prominent ground cover is a mixture of vegetation consisting of sagebrush (*Artemisia tridentata*) and a variety of grasses. Lanceleaf rabbitbrush (*Crysothamnus*

a. The measurements for this section were originally made in United States (U.S.) customary units. Where conventional, the measurements are also shown in the International System of Units (SI) and the correct number of significant digits preserved. Flow rates and specifications have not been converted.

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viscidiflorus) covers about 80% of the INEEL and can be found in any given area. The soil at the INEEL TFF site is previously disturbed sandy gravel and the flat terrain precludes erosion.[b]

INTEC is located on an alluvial plain approximately 200 ft (61 m) from the Big Lost River channel near the point the channel intersects with Lincoln Boulevard on the INEEL. The INTEC is surrounded by a storm-water drainage ditch system (DOE-ID 1998). Storm-water runoff from most areas of INTEC flows through ditches to an abandoned gravel pit on the northeast side of INTEC. From the gravel pit, the runoff infiltrates the ground. The system is designed to handle a 25-yr, 24-hr storm event. Because the land is relatively flat (slopes of generally less than 1%) and annual precipitation is low, storm-water runoff volumes are small, generally spread over large areas, and evaporate or infiltrate the ground surface.

B-1.2 Demography

Population growth surrounding the INEEL (i.e., within a seven-county region comprised of Bannock, Bingham, Bonneville, Butte, Clark, Jefferson, and Madison counties) has paralleled statewide growth from 1960 to 1990. During this time, the regional population increased an average of approximately 1.40% annually, while the annual growth rate for the state was 1.53% (Department of Commerce 1995). From 1990 to 1999, state population growth accelerated to nearly 2.45% per year, but the regional population growth dropped to 1.32% (Department of Commerce 2000). Population growth for the state is projected to slow after the year 2000 (Department of Commerce 1997). Table B-1 lists 1990 and 2000 census data for the counties surrounding the INEEL, and growth projections for 2010 and 2025. The projections are based on an annual growth rate of 1.05% derived from the average of the projected state growth rates from 2000 to 2025 (Department of Commerce 1997).

Bannock and Bonneville counties have the largest populations in the region, and together accounted for 46.9% of the total regional population in the year 2000 (Department of Commerce 2001). Butte and Clark are the most sparsely populated counties and together contained 1.57% of the regional population in 2000. The largest cities in the region are Pocatello (Bannock County) and Idaho Falls (Bonneville County), with year 2000 populations of approximately 51,466 and 50,730, respectively.

The nearest populated area to the INEEL is Atomic City, population 25 (Department of Commerce 2001), located approximately 1 mi (2 km) from the southern INEEL boundary and 11 mi (18 km) from INTEC. No permanent residents live within a 10-mi (20-km) circle centered at INTEC on the INEEL (DOE 1999c). No cities or towns are within 10 mi (20 km) of the INTEC TFF. However, several INEEL facilities, such as CFA, TRA, and RWMC are within 10 mi (20 km) of the INTEC TFF. Also, EBR-I, a National Historic Landmark, is located southwest and within 10 mi (20 km) of the INTEC TFF.

The INEEL has become a major part of the eastern Idaho community and economy. During fiscal year 2001, the Lab employed an average of over 8,000 people and had a budget of nearly $1 billion (INEEL 2001a). The INEEL contractors are the largest employers in the area and one of the five largest in the state. The 2001 impact analysis indicates that INEEL activities and its workforce support an additional 10,250 jobs statewide (INEEL 2001a). Therefore, over 18,000 Idaho jobs can be attributed to the facility. The INEEL workforce is projected to decrease by approximately 450 people by fiscal year 2005 (INEEL 2001b).

About 4,110 workers are employed within 10 mi (20 km) of the INTEC.

B-1.3 Land Use

INEEL occupies land in Bingham, Bonneville, Butte, Clark, and Jefferson counties in southeastern Idaho (see Figure B-1). Approximately 2% of this land (11,400 acres [4,610 ha]) has been developed to support INEEL

b. DOE-ID, 1999a, *Idaho High-Level Waste & Facilities Disposition Draft Environmental Impact Statement*, DOE/EIS-0287D, U.S. DOE Idaho Operations Office, Idaho Falls, Idaho, December.

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Table B-1. Regional population of the INEEL—selected years 1990–2025.

County	1990[a]	2000[b]	2010	2025
Bannock	66,026	75,565	83,886	98,116
Bingham	37,583	41,735	46,329	54,187
Bonneville	72,207	82,522	91,608	107,147
Butte	2,918	2,899	3,217	3,762
Clark	762	1,022	1,135	1,328
Jefferson	16,543	19,155	21,264	24,870
Madison	23,674	27,467	30,491	35,663
Total	219,713	250,365	277,930	325,073

a. Source: Department of Commerce 1990.

b. Source: Department of Commerce 2001.

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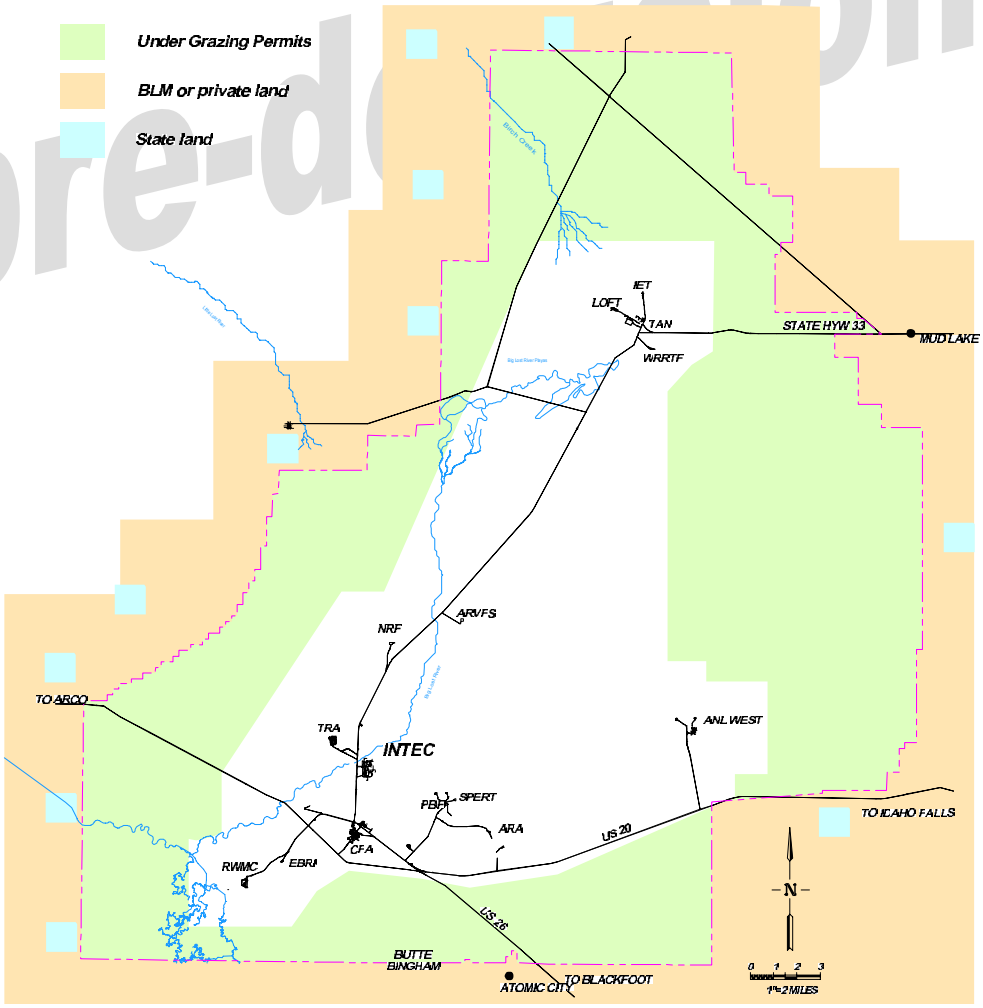

Figure B-1. Selected land of the INEEL and surrounding vicinity.

facility and program operations associated with energy research and waste management activities (DOE 1995). INEEL operations are performed within the primary facility area (i.e., CFA, TRA, INTEC, etc.), which occupies 2,032 acres (822.3 ha). A 345,000-acres (140,000-ha) security development area, which also accommodates environmental research and ecological and socio-cultural preservation.

Approximately 6% of the INEEL (34,000 acres [14,000 ha]) is devoted to utility rights-of-way and public roads. Highways include: Highway 20, which runs east and west and crosses the southern portion of INEEL; Highway 26 that runs southeast and northwest and intersects Highway 20; and Idaho State Highways 22, 28, and 33 that cross the northeastern part of INEEL (DOE 1995).

B-1.3.1 Adjacent Lands

Up to 340,000 acres (140,000 ha) of the INEEL are leased for cattle and sheep grazing (DOE 1995); grazing permits are administered by the Bureau of Land Management (BLM). However, grazing of livestock is prohibited within 0.5 mi (0.8 km) of any primary facility boundary and within 2 mi (3 km) of any nuclear facility. In addition, 900 acres (364 ha) located at the junction of Idaho State Highways 28 and 33 are used by the U.S. Sheep Experiment Station as a winter feedlot (DOE-ID 1997a). Figure B-1 shows land use in the vicinity of the INEEL.

On July 17, 1999, the Secretary of Energy and representatives of the U.S. Fish and Wildlife Service, BLM, and Idaho State Fish and Game Department designated 73,263 acres (29,650 ha) of the INEEL as the Sagebrush Steppe Ecosystem Reserve. The National Biological Service listed the sagebrush steppe ecosystem as critically endangered across its entire range in 1995. The INEEL Sagebrush Steppe Ecosystem Reserve was designated to ensure this portion of the ecosystem receives special scientifically controlled consideration. Conservation management in this area is intended to maintain the current vegetation and provide the opportunity for study of an undisturbed sagebrush steppe ecosystem. Traditional rangeland uses, such as livestock grazing, which currently exist in a portion of the area, will be allowed to continue under this management designation. The designated INEEL Sagebrush Steppe Ecosystem Reserve is located in the northwest portion of the area. The southern boundary of the reserve, which runs east and west is located approximately 11 mi (17 km) north of INTEC at the closest point (DOE-ID 1999a).

Recreational uses of the INEEL include public tours of general facility areas and the EBR-1 landmark. Controlled hunting is also permitted on INEEL but is restricted to 0.5 mi (0.8 km) inside the site boundary. These controlled hunts are intended to assist the Idaho Department of Fish and Game in reducing crop damage caused by wild game on adjacent private agricultural lands. The INEEL is designated as a National Environmental Research Park, functioning as a field laboratory for ecological research and evaluation of the environmental impacts from nuclear energy development (DOE-ID 1999a).

INEEL does not lie within any of the land boundaries established by the Fort Bridger Treaty of 1868. The entire INEEL is land occupied by DOE; therefore, the provision in the Fort Bridger Treaty that allows the Shoshone-Bannock Tribes to hunt on unoccupied lands of the United States does not presently apply to any land upon which INEEL is located (DOE-ID 1999a).

Approximately 75% of the land adjacent to the INEEL is owned by the federal government and administered by the BLM. Land use consists of wildlife management, mineral and energy production, grazing, and recreation. The State of, Idaho owns approximately 1% of the adjacent land, which is also used for wildlife management grazing, and recreation. The remaining 24% of the land adjacent to the INEEL is privately owned and is primarily used for grazing and crop production (INEEL 1999a).

Small communities and towns located near the INEEL's boundaries include Mud Lake to the east; Arco, Butte City, and Howe to the west; and Atomic City to the south. The larger communities of Idaho Falls (with Ammon), Rexburg, Blackfoot, and Pocatello (with Chubbuck) are

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located to the east and southeast, respectively, of the INEEL site. The Fort Hall Indian Reservation is located southeast of the INEEL site.

Recreation and tourist attractions in the region surrounding the INEEL include Hell's Half Acre Wilderness Study Area, Black Canyon Wilderness Study Area, Camas National Wildlife Refuge, Market Lake State Wildlife Management Area, North Lake State Wildlife Management Area, Targhee and Challis National Forests, Sawtooth National Recreation Area, Sawtooth Wilderness Area, Sawtooth National Forest, Grand Teton National Park, Jackson Hole recreation complex, and the Snake River. The four most prominent tourist and recreation areas, or attractions, in the INEEL area include Yellowstone National Park, which is approximately 72.5 mi (117 km) northeast of the INEEL and 99.5 mi (160 km) from the INTEC; EBR-1, which is situated on the INEEL; Craters of the Moon National Monument, which is located approximately 19 mi (30 km) southeast of the INEEL; and the resort areas of Ketchum and Sun Valley, which are approximately 59.5 mi (95.8 km) west of the INEEL (72 mi [120 km] from the INTEC) (INEEL 1999a).

All county plans and policies encourage development adjacent to previously developed areas to minimize the need to extend infrastructure improvements and to avoid urban sprawl. Because the INEEL is remotely located from most developed areas, INEEL lands and adjacent areas are not likely to experience residential and commercial development, and no new development is planned near the INEEL site. However, recreational and agricultural uses are expected to increase in the surrounding area in response to greater demand for recreational areas and the conversion of rangeland to cropland (DOE-ID 1995b).

B-1.3.2 INEEL Projected Land Use

Land use at the INEEL is in a state of transition. Emphasis is moving toward radioactive and hazardous waste management, environmental restoration, remedial technologies, and technology transfer, resulting in more development of INEEL within some facility areas and less development in others.

The *Idaho National Engineering and Environmental Laboratory Comprehensive Facility and Land Use Plan* (DOE-ID 1997a) and the *INTEC Final Record of Decision* (DOE-ID 1999b) described the land use for the INEEL and INTEC. Land use at the INEEL is currently government-controlled industrial use. The term 'controlled' means that unrestricted public access to the INTEC and the INEEL is not available. Presently, access to INEEL facilities requires proper clearance, training, or escort and controls to limit the potential for unacceptable exposures. A security force is used to limit access to approved personnel and visitors. These controls are assumed to be in place for the next 100 yr.

Future land use scenarios are identified in *Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995b). These scenarios were developed and documented using a stakeholder process that involved a public participation forum, a public comment period, and the INEEL Citizens Advisory Board. Following review and comment by the public participation forum, the document underwent a 30-day public comment period and was subsequently submitted to the Citizens Advisory Board for review and recommendations.

Information from these documents was incorporated into the *INEEL Infrastructure Long-Range Plan* (INEEL 2001c). This plan identifies the infrastructure needs of all the major INEEL facilities. Facility organizations, such as INTEC, determined programmatic needs and compared them against the availability and capability of the current infrastructure. Based on this information, the plan identifies projected future requirements.

B-2. METEOROLOGY

Since 1949, meteorological data have been collected periodically at over 45 locations on and near the INEEL. The longest and most complete record of air temperature and precipitation observations was collected over a period of 35 yr from the weather station at CFA. The National Oceanic and Atmospheric Administration

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(NOAA) Air Resources Laboratories conduct most of the meteorological monitoring within 50 mi (80 km) of the INEEL. An overview of climatological data is available from summaries of the data collected from the CFA monitoring station, which is located approximately 3 mi (5 km) south of INTEC. Differences in climate, if any, between the CFA monitoring station and INTEC would be exhibited by small local variations. INTEC and CFA are located at approximately the same elevation and have the same exposure to wind, snow, and cloud cover. A summary of the climatology of the INEEL is available in *Climatography of the Idaho National Engineering Laboratory* (Clawson et al. 1989).

B-2.1 Temperature

Temperature at the INEEL varies widely over the course of the year. Records for CFA indicate that the highest and lowest daily temperature maximums range from 38° C to –44° C (101° F to –47° F). The average annual temperature at the INEEL exhibits a gradual 7-month increase beginning with the first week in January and continuing through the third week in July. During the summer months of April through October, the average monthly temperature varies from 5 to 20° C (41 to 68° F). The temperature then decreases over the course of five months until the minimum average temperature is again reached in January. During the winter months of November through March, the average monthly temperature varies from –9 to –1° C (15 to 30° F). A winter thaw has occurred on a number of years in late January. This thaw is often followed by more cold weather until the spring thaw (DOE-ID 1993).

B-2.2 Wind

The prevailing wind direction at INTEC, and at most locations on the INEEL, is from the southwest (DOE-ID 1993). In summer, a sharp reversal in wind direction occurs daily; winds from the southwest predominate during daylight hours and northeasterly winds predominate at night. The reversals normally occur shortly after sunrise and sunset.

The average monthly wind speed varies from approximately 3.1 mph (8 km/hr) in December to 9.3 mph (15 km/hr) in April and May (DOE-ID 1993). The greatest hourly-average speed was 51 mph (82 km/hr), from the west-southwest. Strong wind gusts can occur in the immediate vicinity of thunderstorms, which on the average, occur two or three days per month during June, July, and August. The fastest instantaneous speed, recorded 18 ft (5.5 m) aboveground at CFA, was 78 mph (126 km/hr), with the wind from the west-southwest. Calm conditions occur 11% of the time.

Atmospheric particulate is routinely monitored using several low-volume air sampling stations, at various locations across the INEEL, and one total suspended particulate monitor at CFA. In 1989 and 1990, the INEEL mean value from the low-volume air samplers ranged from 17 to 20 $\mu g/m^3$, and the CFA annual average ranged from 28 to 40 $\mu g/m^3$ (Hoff et al. 1990; 1991).

B-2.3 Precipitation

The average annual precipitation at CFA is 8.7 in. (22 cm). The greatest recorded annual amount of precipitation recorded was 14.4 in. (36.6 cm) in 1963, and the smallest amount was 4.5 in. (11 cm) in 1966. A precipitation peak of approximately 1.2 in./mo (3 cm/mo) is associated with thunderstorms in May and June each year (DOE-ID 1993). The remaining months generally receive one-half or less of this amount.

Snowfall is a substantial contributor to total annual precipitation. Snowfall and snow depth records are available from the CFA monitoring station. Snowfall ranges from 6.7 to 60 in./yr (17 to 200 cm/yr) with an annual average of 28 inches (71 cm). Although snow occurs mostly during November through April, it does occasionally fall during May, September, and October (Clawson et al. 1989). The maximum average monthly snowfall is 6.4 in. (16 cm) and occurs in December. The water content of melted snow probably contributes between one-quarter and one-third of average annual precipitation (DOE-ID 1993).

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B-2.4 Evaporation

The potential annual evaporation from a saturated ground surface at the INEEL is approximately 36 in. (91 cm), with 80% of the evaporation occurring between May and October. During July, the warmest month of the year, the daily potential evaporation rate is approximately 0.2 in. (0.5 cm) (Hull 1989). Evaporation occurring during the remainder of the year is minimal. Actual evaporation rates are much lower than potential rates because the ground surface is rarely saturated. Transpiration by the native vegetation of the Snake River Plain is estimated at 5.9 to 9.1 in./yr (15 to 23 cm/yr). From late winter to spring, precipitation is most likely to infiltrate the ground because of low evapotranspiration rates (Mundorff et al. 1964). For evaporation from surface water bodies (ponds), a pan evaporation rate of approximately 42.9 in./yr (109 cm/yr) has been estimated (Clawson et al. 1989).

B-2.4.1 Relative Humidity

Average relative humidity at CFA ranges from a monthly average minimum of 15% in August to a monthly average maximum of 89% in February and December. On a daily basis, humidity reaches a maximum just before sunrise, at the time of the lowest temperature, and a minimum late in the afternoon, near the time of the highest temperature.

B-2.5 Severe Weather

B-2.5.1 Tornados

In Idaho, tornadoes have been reported only in the spring and summer seasons (April through August). From 1916 through 1957 (a 42-yr period), 19 tornadoes were reported in Idaho. With expanding population and better surveillance methods, the average number of tornadoes per year in Idaho will probably continue to increase slowly, but compared to areas in the Midwest, the tornado occurrence is infrequent. With very few tornadoes occurring each year, the chances of any one location being struck are remote.

National tornado statistics have been compiled that when taken in context with maximum atmospheric moisture content, surrounding geography, and other statistics allow a realistic assessment of tornado risk and establish a value for the maximum credible tornado that may be expected at the INEEL. From 1950 to the present, the NOAA record indicates there have been a total of five funnel clouds sighted within the boundaries of the INEEL. The calculated return period for a tornado on the INEEL with wind speeds exceeding 120 mph (193 km/hr), according to Coats and Murray (1985), is 1.0E+6 yr.

B-2.5.2 Dust Devils

The whirling winds known as ‘dust devils’ are common at the INEEL. These dust devils pick up dust and pebbles and can overturn, blow down, or carry off unsecured objects. Dust devils usually occur on warm sunny days with little or no wind.

B-2.5.3 Hurricanes and Tropical Storms

Because of the moderating influence of the Pacific Ocean and the isolating influence of surrounding mountains, neither hurricanes nor tropical storms occur at the INEEL.

B-2.5.4 Precipitation Extremes

The maximum values recorded at the INEEL during l-hr and 24-hr periods are listed in Table B-2 (NOAA 1984). The high hourly precipitation amounts during May and June were the result of heavy thunderstorms passing over the rain gauge. The maximum for one hour was 1.15 in. (2.92 cm) at Test Area North (TAN). Precipitation amounts greater than 1.0 in./d (3 cm/d) have occurred during ten of the calendar months within the period of record. Some months have had multiple occurrences.

B-3. ECOLOGY

B-3.1 Flora

Ecological data have been collected and used to study the ecology since 1975, when the INEEL was established as a National the flora and the fauna of the INEEL has largely Environmental Research Park. These data are used to assess the

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Table B-2. Greatest precipitation measured at the INEEL (regardless of location).

Month	1-hr[a] (in.)	24-hr[b] (in.)
January	0.18	1.08
February	0.18	0.96
March	0.17	0.61
April	0.24	1.51
May	1.00	1.78
June	1.15	1.73
July	0.24	1.33
August	0.45	1.44
September	0.55	1.55
October	0.34	1.12
November	0.25	1.02
December	0.23	1.18
Maximum	1.15	1.78

a. For the period January 1950 through December 1964, hourly amounts were not available from 1965 through 1982.

b. For the period January 1950 through December 1982.

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effects of human activities on natural systems and provide a basis for analyzing environmental changes as a result of human influence on the environment. Research on been conducted by, or in conjunction with, the DOE Radiological and Environmental Sciences Laboratory. Information in this subsection is summarized from the *Environmental Resource Document for the Idaho National Engineering Laboratory* (Irving 1993).

The physical aspects of the INEEL and its flora and fauna are typical of cold, high altitude, sagebrush steppe ecosystems found in many parts of the western United States. Irving (1993) provides additional detailed information and references to specific ecological studies. The common and scientific names for the flora discussed here are presented in Table B-3. For ease of reading, only the common names are used in this discussion.

Extensive surveys of INEEL vegetation were carried out in 1952, 1958, and 1967 using 150 permanent transect lines established and maintained for this purpose (Harniss and West 1973). McBride et al. (1978) and Jeppson and Holte (1978) have also described vegetation.

The common vegetation type, found on approximately 80% of the INEEL site, is a mixture of big sagebrush, green rabbitbrush, and perennial grasses. Most of the trees on the INEEL site are scattered along the Big Lost River and in the Twin Buttes area. Figure B-2 depicts the distribution of vegetation at the INEEL.

Vegetation in low-lying areas and along playa borders consists primarily of alkaline-tolerant species including shadscale saltbush, nuttal saltbush, and winterfat. Important associated grasses are bottlebrush squirreltail, giant wildrye, and Indian ricegrass. Prickly pear, painted milkvetch, and skeletonweed are common in sandy areas in the north. Willows, baltic rush, and povertyweed grow along the Big Lost River channel.

Several studies have been conducted at the INEEL on plant rooting depths, especially for the RWMC Surface Disposal Area (SDA). Vegetation studies of plant uptake of radionuclides have focused primarily on (a) determining if deep-rooted plants are a mechanism for waste pit intrusion and subsequent uptake of radionuclides and (b) analyzing aerial portions of plants to determine the radionuclide inventory. Aerial portions of plants are important because they can

Table B-3. Flora found at the INEEL.

Common Name	Latin Name
Cactus Family—*Cactaceae*	
Coryphantha	*Coryphantha* sp.
Prickly pear cactus	*Opuntia polyacantha*
Goosefoot Family—*Chenopodiaceae*	
Shadscale saltbush	*Atriplex confertifolia*
Nuttall saltbush	*Atriplex nuttallii*
Winterfat	*Ceratoides lanata*
Summer cypress	*Kochia scoparia*
Povertyweed	*Monolepsis nuttalliana*
Russian thistle	*Salsola kali*
Composite or Aster Family—*Compositae*	
Big sagebrush	*Artemisia tridentata*
Threetip sagebrush	*Artemisia tripartite*
Hoary false-yarrow	*Chaenactis douglasii*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Skeleton weed	*Lygodesmia grandiflora*
Common dandelion	*Taraxacum officinale*
Gray horsebrush	*Tetradymia canescens*
Goatsbeard or yellow salsify	*Tragopogon dubius*
Mustard Family—*Cruciferae*	
Flixweed tansy mustard	*Descurainia sophia*
Grass Family—*Gramineae*	
Crested wheatgrass	*Agropyron cristatum*
Bluebunch wheatgrass	*Agropyron spicatum*
Cheatgrass	*Bromus tectorum*
Giant wildrye	*Elymus cinereus*
Indian ricegrass	*Oryzopsis hymenoides*
Bottlebrush squirreltail	*Sitanion hystrix*
Rush Family—*Juncaceae*	
Baltic rush	Juncus balticus
Pea Family—*Leguminosae*	
Painted milkvetch	*Astragalus ceramicus* Sheld. var. *apus* Barneby
Thistle milkvetch	*Astragalus kentrophyta* Gray var. *kentrophyta*
Woolly-pod milkvetch	*Astragalus purshii* Dougl. var. *ophiogenes* Barneby
Phlox Family—*Polemoniaceae*	
Large-flowered gymnosteris	*Gymnosteris nudicaulis* Greene
Longleaf phlox	*Phlox longifolia*
Buckwheat Family—*Polemoniaceae*	
Buckwheat	*Oxytheca dendroides*,[a] Nutt.
Willow Family—*Salicaceae*	
Willows	*Salix* sp.
Parsley Family—*Umbelliferae*	
Desert parsley	*Lomatium* sp.

a. Source: Hitchcock and Cronquist 1974.

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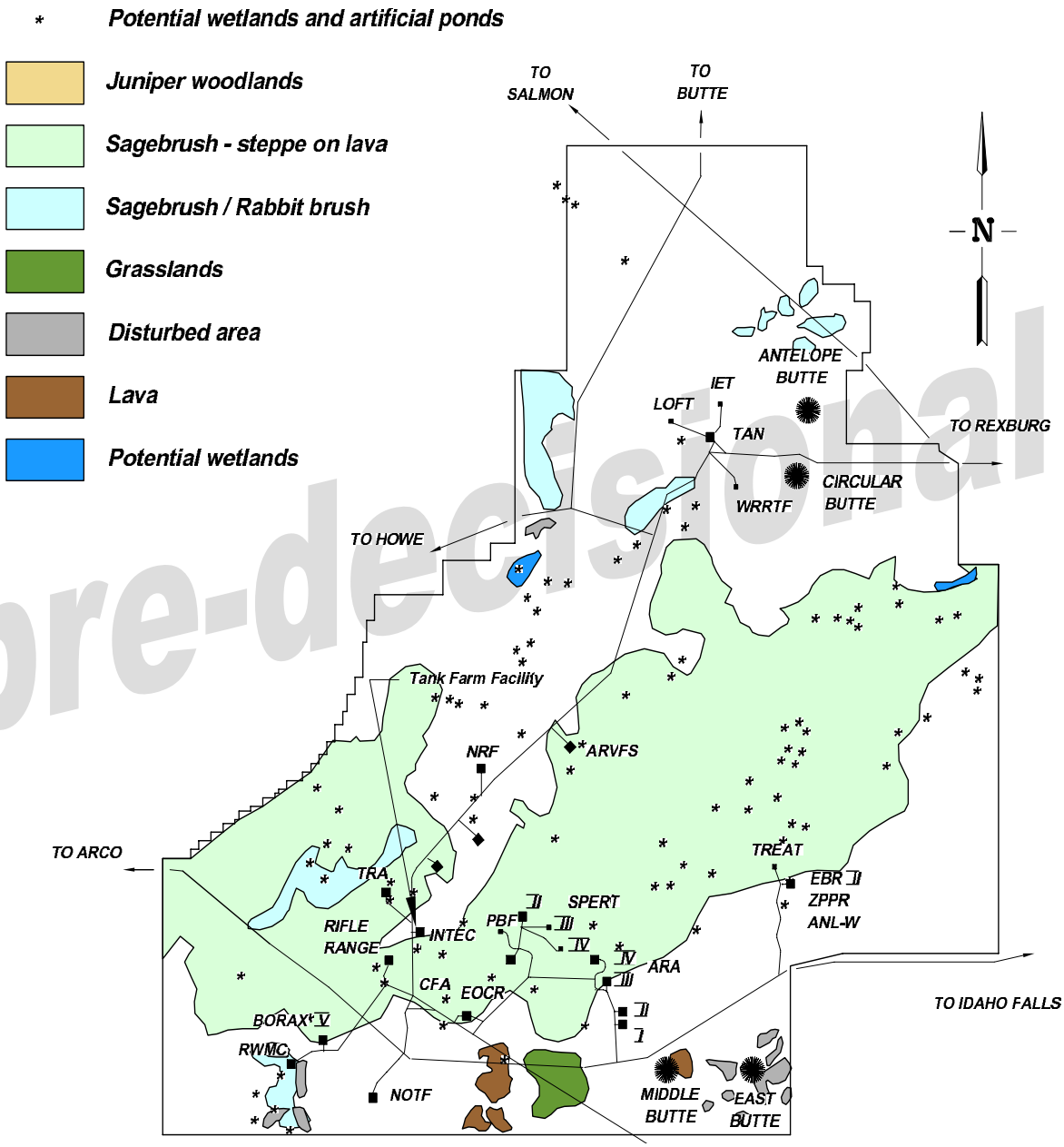

Figure B-2. Distribution of vegetation at the INEEL (DOE-ID 1999a).

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potentially transport subsurface contaminants through dispersal of leaves, consumption by herbivores, and use by birds as nesting materials.

One RWMC SDA study comparing radionuclide uptake by crested wheatgrass (rooting depth 3 to 4.9 ft [0.9 to 1.5 m]) with that by Russian thistle (rooting depth 3 to 16 ft [0.9 to 4.9 m]) and showed higher radionuclide concentrations in the deeper-rooted species (Arthur 1982). Examples of other deep-rooting species are rabbitbrush and sagebrush. General examples of shallow-rooting plant types are grasses and annual forbs.

Reynolds and Fraley (1989) found that the roots of big sagebrush (*Artemisia tridentata*) extended to a depth of 88.7 in. (225 cm), green rabbitbrush (*Chrysothamnus vicidiflorus*) to a depth of 74.9 in. (190 cm), and Great Basin wildrye (*Leymus cinereus*) had roots up to 78.8 in. (200 cm) at the SDA. Maximum lateral spread of the roots of both big sagebrush and Great Basin wildrye was 35.5 in. (90.2 cm) and occurred at a depth of 15.8 in. (40.1 cm). In addition, studies indicate root penetration of up to 5.2 ft (1.6 m) for sodar and crested wheatgrass at the INEEL (Markham 1987).

A survey of rare plants on the INEEL site was initiated in 1980 (Cholewa and Henderson 1984). The survey identified the following: painted milkvetch and woolly-pod milkvetch (which were under federal review for endangered or threatened status); coryphantha, large-flowered gymnosteris, and oxytheca (on the Idaho State Watch List); and thistle milkvetch, which was previously unknown to occur in Idaho. Since then, the two species of milkvetch have been removed from candidate status (Mosely and Groves 1990).

B-3.2 Fauna

A variety of wildlife including small mammals, birds, reptiles, and a few large mammals are supported at the INEEL (Table B-4). The mammals include chipmunks, ground squirrels, and several species of mice, kangaroo rats, cottontail rabbits, bats, jackrabbits, coyotes, and long-tailed weasels. Commonly occurring game animals are sage grouse, mourning dove, elk, pronghorn antelope, and mule deer. Limited data are available on the number of game animals seasonally inhabiting the INEEL and on the harvest of these animals by hunters. Pronghorn antelope inhabit the INEEL during the entire year.

Aquatic life on the INEEL is limited and depends mainly upon the flow of the Big Lost River. During several months of the year, and even during some entire years, the river does not flow. However, during spring runoff and periods of high rainfall, the diversion system (at the southern boundary of the INEEL) and the Big Lost River sinks (at the northern boundary of the INEEL) support water flow during periods of water accumulation. This normally occurs less than two or three months in the spring. Fish species observed in the Big Lost River on the INEEL include rainbow trout, mountain whitefish, eastern brook trout, Dolly Varden char, Kokanee salmon, and the shorthead sculpin (Overton et al. 1976).

An investigation of amphibians and reptiles within the INEEL was conducted from May through September 1975. The Great Basin spadefoot toad was the only amphibian recorded and is typically associated with the Big Lost River, the Big Lost River sinks, and the spreading areas near the RWMC (Reynolds et al. 1986). The sagebrush lizard and the short-horned lizard are common; the sagebrush lizard is the most abundant reptile. The western skink and the leopard lizard have also been observed. Four species of snakes, including the Great Basin rattlesnake and Great Basin gopher snake, were recorded. The western terrestrial garter snake and the desert striped whipsnake are present in lesser numbers and have more restricted distributions.

A total of 740 insect species have been recorded at the INEEL; 226 of these species have not yet been identified beyond the family level. The majority of the abundant species belong to the orders Hymenoptera (wasps and ants) and Diptera (flies). About one-half of the abundant species are parasitic or predatory.

Over 185 species of birds have been recorded on the INEEL, and about 60 of these species

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Table B-4. Fauna at the INEEL.

Common Name	Latin Name
Fish[a]	
Rainbow trout	*Salmo gairdneri*
Eastern brook trout	*Salvelinus fontinalis*
Dolly varden char	*Salvelinus malma*
Kokanee salmon	*Oncorhynchus nerka*
Mountain whitefish	*Prosooium williamsoni*
Shorthead sculpin	*Cottus confusus*
Reptiles and Amphibians[b]	
Leopard frog	*Rana pipiens*
Great Basin spadefoot toad	*Spea intermontanus*
Leopard lizard	*Gambelia wislizenii*
Sagebrush lizard	*Scel6porus graciosus*
Short-horned lizard	*Phrynosoma douglassi*
Western skink	*Eumeces skiltonianus*
Desert-striped whipsnake	*Masticophis taeniatus*
Great Basin gopher snake	*Pituophi-s melanoleucus*
Western Terrestrial garter snake	*Thamnophis elegans*
Great Basin rattlesnake	*Crotalus viridis*
Mammals[c]	
Family—*Canidae*	
Coyote	*Canis latrans*
Family—*Felidae*	
Bobcat	*Lynx rufus*
Family—*Antilocapridae'*	
Pronghorn	*Antilocapra americans*
Family—*Cervidae*	
Mule deer	*Odocoileus hemionus*
Elk	*Cervus canadensis*
Family—*Vespertilionidae*	
Big-brown bat	*Eptesicus fuscus*
Townsend's big-eared bat	*Plecotus townsendii*
Family—*Leporidae*	
White-tailed jackrabbit	*Lepus townsendii*
Black-tailed jackrabbit	*L. californicus*
Nuttall's cottontail	*Sylvilagus nuttallii*
Family—*Sciuridae*	
Least chipmunk	Tamias minimus
Townsend's ground squirrel	*Spermophilus townsendii*
Family—*Geomyidae*	
Northern pocket gopher	Thomomys talpoides
Family—*Heteromyidae*	
Ord's kangaroo rat	*Dipodomys ordii*
Family—*Cricetidae*	
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*

Table B-4. (continued).

Common Name	Latin Name
Birds[d]	
Family—*Accipitridae*	
Golden eagle	*Aquila chrysaetos*
Ferruginous hawk	*Buteo regalis*
Bald eagle	*Haliaeetus leucocephalus*
Family—*Falconidae*	
Merlin	*Falco columbarius*
Family—*Falconidae*	
Prairie falcon	*Falco mexicanus*
Peregrine falcon	*Falco peregrinus*
Family—*Phasianidae*	
Sage grouse	*Centrocercus urophasianus*
Family—*Scolopacidae*	
Long-billed curlew	*Numenius americanus*
Family—*Strigidae*	
Burrowing owl	*Athene cunicularia*
Family—*Columbidae*	
Mourning dove	*Zenaida macroura*
Family—*Mimidae*	
Sage thrasher	*Oreoscoptes montanus*
Family—*Tyrannidae*	
Say's phoebe	*Sayornis saya*
Family—*Alaudidae*	
Horned lark	*Eremophila alpestris*
Family—*Emberizidae*	
Western meadowlark	*Sturnella neglecta*
Sage sparrow	*Amphispiza belli*
Brewer's sparrow	*Spizella breweri*

a. Source: Simpson and Wallace (1978)
b. Source: Nussbaum, Brodie, and Storm (1983)
c. Source: Jones, Carter, and Genoways (1979)
d. Source: American Ornithologist's Union (1983).

probably breed on the INEEL. However, many of the bird species are relatively uncommon, and only a few species are abundant. The most common species are the Brewer's sparrow, sage thrasher, sage sparrow, horned lark, sage grouse, mourning dove, western meadowlark, blackbilled magpie, and robin (Reynolds et al. 1986).

Species that merit special consideration because of their sensitivity to disturbance or their threatened status include the ferruginous hawk, merlin, long-billed curlew, Townsend's big-eared bat, common loon, white pelican, great egret, and trumpeter swan (Reynolds et al. 1986; Mosely and Groves 1990). The bald eagle and peregrine falcon are on the Federal Endangered Species List and occasionally visit the INEEL.

Studies have been performed on burrowing characteristics of small mammals such as ground squirrels, deer mice, and voles (Arthur et al. 1983; Markham 1987; Reynolds and Laundre 1988). Results of the studies indicate burrows no deeper than 55 in. (140 cm) at the INEEL.

B-4. GEOLOGY

The INEEL is located on the west-central part of the eastern Snake River Plain, a northeast-trending structural basin about 200-mi (300-km)

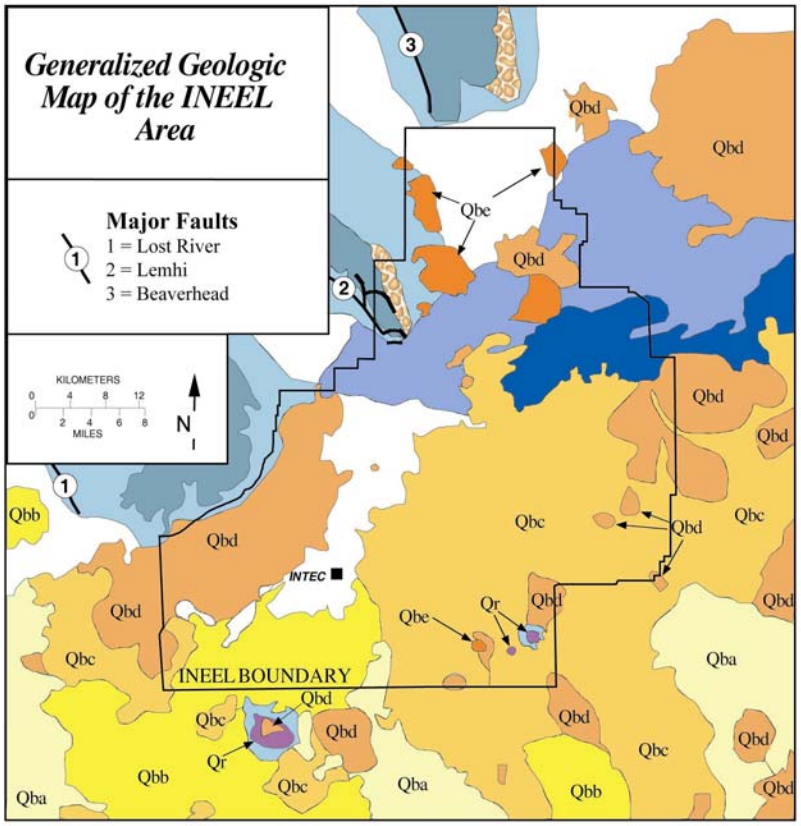
long and 50 to 70-mi (80 to 100-km) wide (see Figure B-3). The INEEL is underlain by a sequence of Tertiary and Quaternary volcanic rocks and sedimentary interbeds that are more than 10,000-ft (3,000-m) thick (Whitehead 1992). The volcanic rocks consist mainly of basalt flows in the upper part of the sequence and rhyolitic ash-flow tuffs in the lower part. Basalt and sediment generally range in age from about 200 thousand to 4 million years before present (Anderson et al. 1997) and underlie the plain to depths ranging from about 2,200 to 3,800 ft (670 to 1,200 m) below ground level (BGL).

Hundreds of basalt flows, basalt-flow groups, and sedimentary interbeds underlie the INEEL. Basalt makes up about 85% of the volume of deposits in most areas. A basalt flow is a solidified body of rock formed by the surficial outpouring of molten lava from a vent or fissure (Bates and Jackson 1980). A basalt-flow group consists of one or more distinct basalt flows deposited during a single, brief eruptive event. All basalt flows of a group erupted from the same vent or several nearby vents; represent the accumulation of one or more lava fields from the same magma; and have similar geologic ages, paleomagnetic properties, potassium contents, and natural-gamma emissions (Anderson and Bartholomay 1995). The basalt flows consist mainly of medium- to dark-gray vesicular to dense olivine basalt. Individual flows generally range from 10 to 50-ft (3 to 20-m) thick and are locally interbedded with scoria and thin layers of sediment. Sedimentary interbeds are as thick as 50 ft (20 m) and consist of well-sorted to poorly-sorted deposits of clay, silt, sand, and gravel. In places, the interbeds contain or consist mainly of scoria and basalt rubble. Sedimentary interbeds accumulated on the ancestral land surface for hundreds to hundreds of thousands of years during periods of volcanic quiescence and are thickest between basalt-flow groups.

At least 178 basalt-flow groups and 103 sedimentary interbeds underlie the INEEL above the effective base of the Snake River Plain Aquifer (SRPA) (Anderson et al. 1996; Anderson et al. 1997). Basalt-flow groups and sedimentary interbeds are informally referred to as A through S5. Basalt-flow groups LM through L and related sediments range in age from about 200 to 800 thousand years and make up the unsaturated zone and the upper-most areas of the INEEL. Most wells in the southern and the eastern parts of the INEEL are completed in basalt-flow groups AB through I, and related sediments. Flow groups AB through I, and related sediments, range in age from about 200 to 640 thousand years and make up a stratigraphic section characterized by horizontal to slightly inclined layers. Anderson et al. (1997) estimated the geologic ages and accumulation rates of basalts and sediments in the unsaturated zone and the SRPA from about 200 thousand to 1.8 million years and average accumulation rates reflective of the subsidence rate of 164 ft (50 m)/100,000 yr.

The nomenclature for the stratigraphy underlying the INTEC facility and the surrounding area is based on work presented by Anderson (1991). A north-south geologic cross section, illustrated in Figure B-4, forms the framework for the conceptual model and numerical simulations in the TFF PA.

The stratigraphy of the aquifer at and near the INTEC is dominated by thick massive-basalt flows of flow group I and thin, overlying flows of flow groups B through H. The basalt flows, as interpreted, appear to be relatively uniform in thickness beneath the INTEC. Significant changes in the flow thickness are often related to changes in the lithology of the flow or are caused by the flow margins in which the flow appears as a lobe of basalt. The lithologic changes that may cause a change in the flow thickness are the existence of pyroclastic deposits on or within a flow, or a flow being very vesicular, and thus, more susceptible to the effects of erosion. Based on the Anderson (1991) geologic cross section, 19 basalt flow groups, 11 sedimentary interbeds, and surficial alluvium make up the unsaturated zone and upper aquifer underlying the INTEC facility. The sediments, as interpreted, appear to be primarily made up of sands and silts with some small clay lenses. The majority of the sediments are 1 to 5-ft (0.3 to 2-m) thick layers of silt between the major basalt flows. Sediments were most likely deposited in eolian or fluvial type environments. Two major sediment sequences are shown on the cross sections: the upper sequence associated with



Deposits

Mainstream Alluvium. Includes deposits of modern floodplains (Holocene) and older deposits in terraces above modern floodplains (upper to middle Pleistocene). Composed mostly of gravel and sand with minor silt and clay. Older deposits host well-developed soils and partial to complete loess cover. Up to 20 m thick in southern INEEL, and much thicker in mainstreams to the north.

Alluvial Fans Deposits. Debris flow and stream deposits of clast-supported pebble and boulder gravels with matrix of silty sand to clayey silt (Holocene to upper Pliocene). Middle to lower Pleistocene units commonly locally faulted along the west flanks of the Lost River, Lemhi, and Beaverhead ranges. Includes colluvial debris fans on steep slopes of East, Middle, and Big Southern Buttes.

Eolian Deposits. Very fine to coarse sand in mostly stabilized dunes, 1 to 5 m thick. Some areas of active deflation and migrating sand (Holocene to upper Pleistocene).

Lacustrine Deposits. Mostly lake-floor deposits of Pleistocene Lake Terreton. Silty clay to sandy silt, 1 to >100 m thick. Locally includes sandy lake margin deposits and Holocene playa deposits.

Bedrock Units

Basaltic Lava Flows. Black to gray pahoehoe and 'a'a lava flows, with bedded, oxidized, scoria, cinders, and ash near vents. Locally weathered and oxidized. Olivine basalts composed of crystals of olivine, pyroxene, plagioclase, titanomagnetite, and ilmenite in a matrix of brown glass.

Qba Holocene to uppermost Pleistocene (<15K yr). No cover of eolian or alluvial deposits.

Qbb Upper to Middle Pleistocene (15–200K yr). Locally covered by up to 1 m of eolian sand and loess.

Qbc Middle Pleistocene (200–400K yr). Covered by as much as several meters of eolian sand and loess.

Qbd Middle to Lower Pleistocene (400–730K yr). Mostly covered by several meters of eolian sand and loess.

Qbe Lower Pleistocene (>730K yr). Mostly covered by several meters of eolian sand and loess. Reversed magnetic polarity.

Quaternary Rhyolite

Qr **Rhyolite Domes.** Pleistocene (0.3–1.2M yr) tan to pink, flow laminated rhyolite, with minor vent breccia and banded obsidian composed of microcrystalline intergrowths of quartz, and alkali feldspar with rare phenocrysts of quartz clinopyroxene and magnetite.

Tertiary Volcanics

Volcanic Rocks. Basaltic lava flows, rhyolitic ash flow tuffs, and rhyolitic lava flows. Mostly Miocene and Pliocene (about 4–12M yr).

Pre-Tertiary Rocks

Pre-Tertiary Rocks. Late Precambrian to Triassic. Mostly Mississippian shelf carbonates of the Overthrust Belt. Also includes Permian to Triassic fine clastic deposits and phosphatic silts; Cambrian to Ordovician quartzites, sandstone, conglomerates, and siltstones; Devonian dolostones and argillites; and Precambrian sandstones and quartzites.

Figure B-3. Generalized geologic map of the INEEL area.

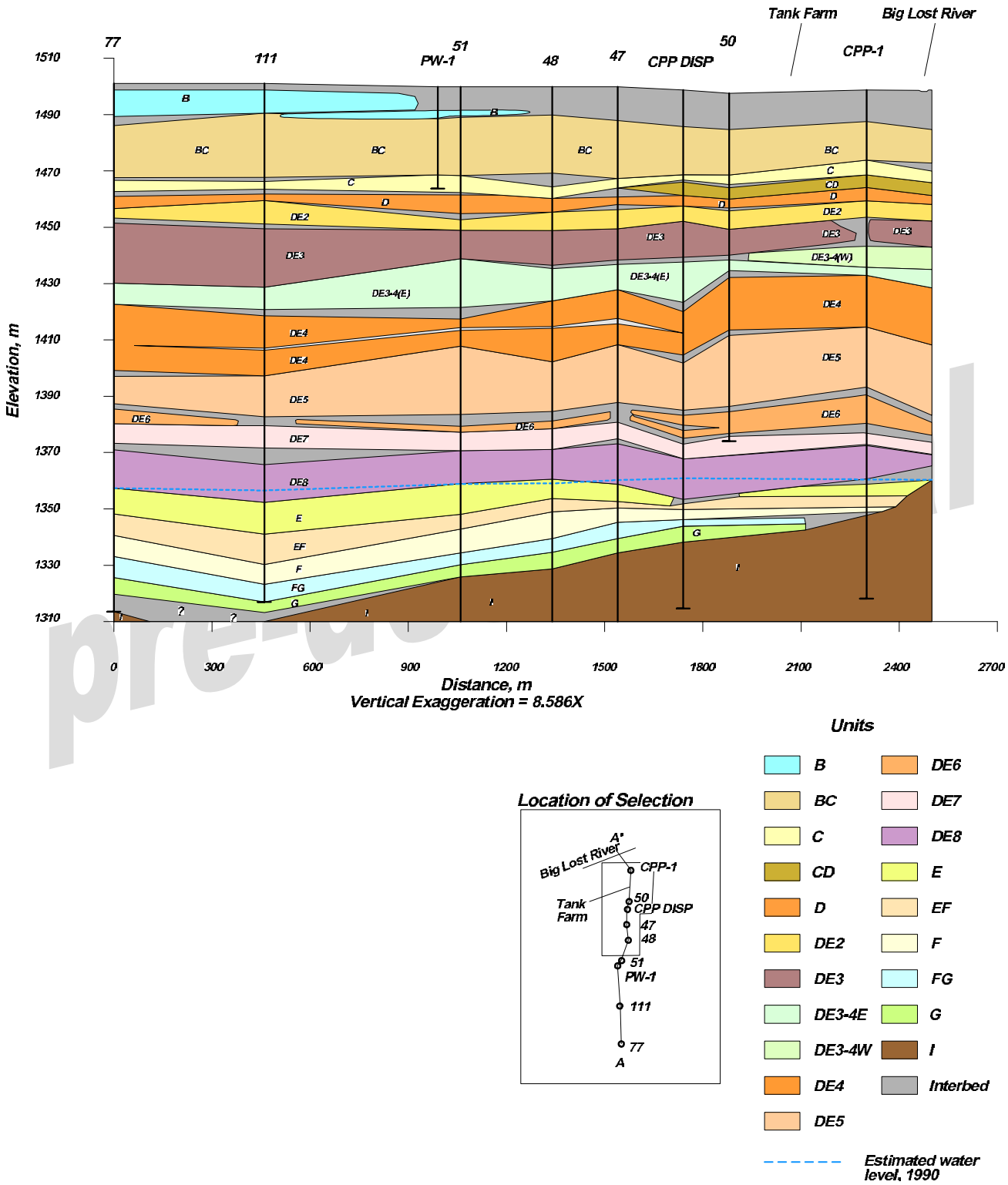


Figure B-4. Geologic cross section, north to south.

the CD, the thick D, and DE2 sands and silts, and the lower sediments associated with the DE6, DE7, and DE8 stratigraphic units. The cross section shows a very thick sequence of sediments, particularly in the northern end of the south-north section, which are shown as the CD, D, and DE2 units. These sediments appear to be a thick sequence of sands over and underlain by silts and clays. The sediments associated with the DE6, DE7, and DE8 stratigraphic units appear to be made up of gravels, silts, and clays. These sediments were most likely deposited in a fluvial environment and may indicate a braided stream deposit. This is the last major sediment deposit above the SRPA.

Holocene surficial geology and archaeology suggest that fluvial and eolian deposition and tectonic subsidence in the INEEL area have been in approximate net balance for at least the past 10,000 yr. A reversal of the long-term, regional pattern of East Snake River Plain (ESRP) subsidence, sedimentation, and volcanism into an erosional rather than a depositional regime would require major changes from the Holocene tectonic or climatic configuration of the ESRP. Worldwide geologic evidence indicates that the Quaternary epoch (approximately the past 2M yr) has been a time of major climatic fluctuations. During colder and wetter periods, glaciers occupied high-elevation areas, and lowland areas such as the ESRP received thick, widespread loess blankets. Lowland areas were also periodically impacted by local catastrophes such as the large, late-Pleistocene, glacial outburst flood, which traveled down the Big Lost River valley, eroded upland surfaces on the ESRP, and deposited sediment in the INTEC area. If the future ESRP climate were to become warmer and more arid, the probable consequences would be decreased vegetation and increased eolian transport of fine-grained sediment, mainly as longitudinal sand dunes.

Future climate fluctuations on the ESRP, to either colder and wetter or warmer and drier conditions, are not expected to erode the INTEC land surface. Quaternary geologic and Holocene archaeological data suggest the INEEL area will probably continue its long-term history of regional subsidence and net accumulation of sedimentary and volcanic materials, although sedimentation patterns on the ESRP will change in response to future climate fluctuations.

INTEC soil cover erosion could occur as a consequence of faulting and uplift, but this erosion would involve a major change in the Quaternary tectonic configuration of the ESRP. Therefore, this scenario is improbable within the next 10,000 yr considering the regional seismicity and tectonic history of the INEEL area, the absence of Quaternary tectonic faults on the ESRP in the vicinity of the INEEL, and the long response time for significant erosion to occur as a result of protracted faulting and uplift.

Anderson (1991) and Anderson et al. (1997) present more detailed discussions of the INEEL's geology and stratigraphy. In summary, the following impacts from volcanic and tectonic activity are relevant to the INTEC TFF closure:

- During the past 4M yr, the ESRP and the INTEC area have undergone regional subsidence, basaltic volcanism, and fluvial and eolian sedimentation. Erosion has not been a significant process on the ESRP.

- Surficial and subsurface-geologic data indicate that the INTEC area has both subsided and accumulated basalt lava flows and sediments at an average rate of 0.012 in. (0.3 mm) per year. Significant uplift or erosion has not interrupted this long-term trend.

- Lava inundation or magma intrusion associated with volcanism from the nearby Arco Volcanic Rift Zone is improbable considering the volcanic history of the area, and lava inundation or magma intrusion would not likely result in the release of radionuclides to the environment.

B-4.1 Seismology

The seismically active Intermountain Region surrounds the ESRP and Centennial Seismic Belts. The Intermountain Seismic Belt is a zone of concentrated seismicity that extends from northwestern Montana through eastern Idaho, and Utah, into southern Nevada. The Centennial

predecisional

Seismic Belt, also a seismically active zone, extends from the Hebgen Lake, Montana, area westward into central Idaho. The INEEL, U.S. Geological Survey (USGS), Montana Bureau of Mines and Geology, United States Bureau of Reclamation, and the University of Utah seismograph stations have compiled earthquake data from 1884 to 1989. The distribution of epicenters indicates that the Snake River Plain is devoid of earthquakes relative to the active areas surrounding it with the possible exception of the 1905 earthquake located at Shoshone, Idaho. Historical records suggest that the epicenter for the 1905 earthquake is not located within the Snake River Plain but rather near the Idaho–Utah border. A large earthquake in the vicinity of the INEEL occurred in the Centennial Seismic Belt on October 28, 1983, and it had a surface-wave magnitude of 7.3. The earthquake resulted from slippage along the Lost River fault—a northwest rupture along a normal fault with relative vertical movement downward to the west. The epicenter for this event was located in the Thousand Springs Valley near the western flank of Borah Peak, approximately 55 to 60 mi (89 to 97 km) from INEEL facilities. Substantial damage occurred to masonry structures in the local communities of Mackay and Challis near the epicentral area. Although the earthquake ground motions were felt at the INEEL site, and peak ground accelerations ranging from 0.022 to 0.078 g were recorded at several INEEL facility areas, only minor nonnuclear building damage occurred in the form of hairline cracks and settlement (Gorman and Guenzler 1983). The INTEC did not experience structural failures or waste spills as a result of the earthquake and the waste storage facilities did not show evidence of permanent movement or resulting damage (Jackson 1985). During the earthquake, the INEEL was located in Zone VI (Modified Mercalli Intensity Scale), which is defined as including objects falling and moving and slight damage occurring in poorly built buildings; however there is usually no structural damage.

The largest earthquake in the region occurred on August 17, 1959, at Hebgen Lake, Montana, located approximately 120 mi (190 km) northeast of the INEEL site. The event had a surface-wave magnitude of 7.5 and though it was felt at the INEEL, it caused no damage.

The INEEL has maintained a seismic network for monitoring earthquake activity on and around the ESRP since December 1971. Currently, the seismic network consists of 24 seismic stations and 21 strong-motion accelerographs. The seismic stations continually record seismic data, and their data are used to calculate the locations and magnitudes of microearthquakes (magnitude < 3.5) that occur locally. When triggered, the strong-motion accelerographs record earthquake ground motions from local moderate to large earthquakes.

The INEEL seismic network has compiled earthquake data for18 yr, from 1972 to 1990. During this period, approximately 15 microearthquakes have been located within the ESRP, indicating that infrequently-occurring, small magnitude earthquakes (magnitude < 1.3) are characteristic of ESRP seismicity (Jackson et al. 1993; Pelton et al. 1990). These data are in agreement with the historical earthquake data compiled for the surrounding region. Recent modifications to the seismic network, such as placing sensors in 59 to 69-ft (18 to 21-m) boreholes, will lower the magnitude threshold of detecting microearthquakes within the ESRP.

Because the ESRP is seismically active, assessments of seismic hazards are being updated for all facility areas at the INEEL. These assessments are being performed to quantitatively estimate peak ground motions that INEEL facilities may experience from nearby large magnitude earthquakes. Most of the INEEL is located in Seismic Zone 2B, and a small portion is located in Zone 3. The seismic design levels for INEEL facilities exceed those required for these classifications.

Uplift and erosion of the INTEC area could result from faulting and uplift of the southern Lost River Fault, if the fault encroached southward onto the ESRP to a position several miles west of the INTEC. Assuming immediate initiation of this faulting and maximum-uplift rates from the most recently active fault segments of the nearby Basin and Range Province (3 to 7 ft /1,000 yr [1.0 to

preliminary

2.0 m/1,000 yr]), significant uplift and erosion of the INTEC area would require times of 10,000 to 100,000 yr. Additional information on seismic hazards for the region is presented in Irving (1993).

B-4.2 Volcanology

Most of the INEEL is underlain by a 0 to 0.6 mi (0 to 1-km) thick sequence of late Tertiary and Quaternary basalt lava flows and interbedded sediments. Based on drill-hole information, regional mapping along the margins of the ESRP, and geophysical information, the basalt and sediment sequence is underlain by an older section (up to several miles thick) of late Tertiary rhyolitic volcanic rock. These two volcanic sequences are a consequence of the passage of the Yellowstone mantle plume (hotspot) through the INEEL area of the ESRP in late Tertiary time (Malde 1991). The Tertiary rhyolitic volcanic rocks were erupted at 6.5 to 4.3 mega-annum (10^6 yr [Ma]), when the hotspot resided beneath the INEEL. The rocks comprise mostly ash-flow tuffs erupted during large, violent explosive episodes and large rhyolitic lava flows. They are analogous to the ash-flow tuffs and lava flows that were erupted from calderas in the Yellowstone Plateau at 2.0 to 0.6 Ma. These types of large-scale explosive eruptions can occur only directly over the mantle hotspot because large inputs of heat into the lower and middle crust are required to generate such large volumes of rhyolitic magma. Because the hotspot is now situated beneath Yellowstone National Park, recurrence of this type of volcanic activity in the INEEL area is nearly impossible. Residual heat in the upper mantle after passage of the hotspot has continued to produce basaltic magmas that have risen to the surface and erupted onto the subsiding ESRP. Basaltic eruptions in the INEEL area began at about 4 Ma, soon after passage of the hotspot, and have continued with the most recent activity occurring along the Great Rift about 2,100 yr ago.

Basalt vents on the ESRP include broad, nearly circular, low-relief shield volcanoes, small spatter cones, and spatter ramparts along eruptive fissures. Lava fields related to single vents range in surface area from 0.7 to 154 mi^2 (2 to 400 km^2) and in volume from 0.01 to 1.7 mi^3 (0.05 to 7 km^3) (Kuntz et al. 1992). Volcanic vents are not randomly distributed on the ESRP, but they are concentrated in northwest-trending linear zones known as volcanic rift zones (see Figure B-5).

In addition, vents are concentrated in a northeast-trending zone, known as the Axial Volcanic Zone, along the central axis of the ESRP. The Axial Volcanic Zone is a constructional highland caused by more voluminous magma output along the axis of the ESRP.

The Arco Volcanic Rift Zone north of Big Southern Butte was active between 600 and 100 kilo-annum (10^3 yr [ka]) (Kuntz et al. 1992). The Cerro Grande and North and South Robbers flows (10,500 to 12,000 ka) near Big Southern Butte occur at the intersection of the Arco Volcanic Rift Zone with the Axial Volcanic Zone. Except for volcanism along the Great Rift, all of the Holocene volcanic fields of the ESRP occur along the Axial Volcanic Zone (see Figure B-5). Recurrence of volcanism in the ESRP has a greater likelihood of occurring along the Great Rift and the Axial Volcanic Zone. Additional information on the site volcanism is presented in Hackett and Smith (1992).

B-4.3 Geologic Resources

INEEL mineral resources include sand, gravel, pumice, silt, clay, and aggregate. These resources, excavated from several quarries or pits, are used for road construction and maintenance, waste burial activities, and landscaping. The potential for geothermal energy exists at the INEEL; however, a study conducted in 1979 identified no economic geothermal resources (Mitchell et al. 1980).

B-4.4 Natural Background Radiation

Monitoring and assessment activities are conducted to characterize existing radiological conditions at the INEEL and the surrounding environment. Results of these activities show that exposures resulting from airborne radionuclide emissions are well within applicable standards and

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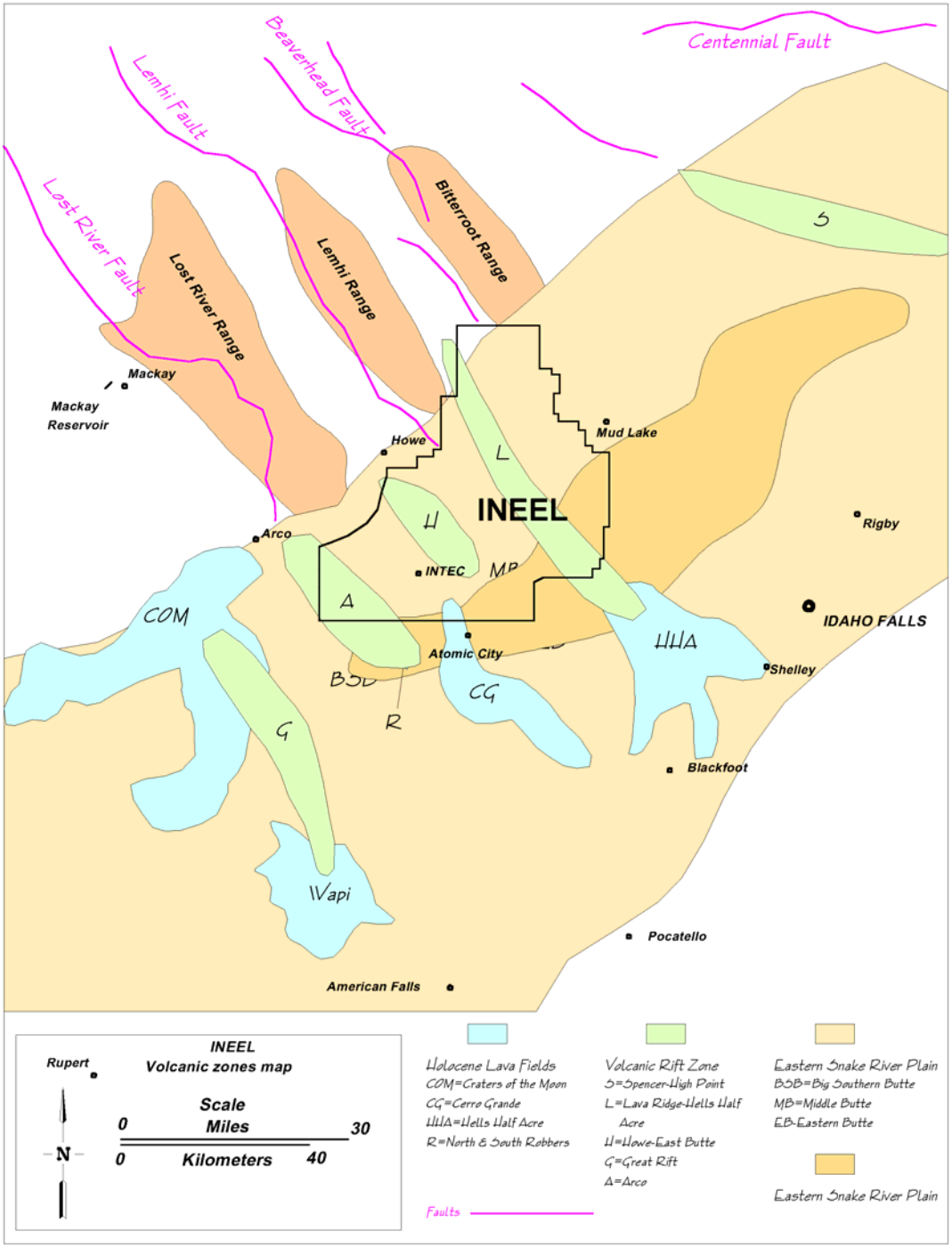

Figure B-5. Volcanic rift zones at the INEEL.

are a small fraction of the dose from background sources.

DOE has compared radiation levels monitored on and near INEEL with those monitored at distant locations to determine radiological conditions. Results from offsite and boundary community locations include contributions from background conditions and INEEL emissions. These data show that over the most recent 5-yr period for which results are available (1992 through 1996), average radiation exposure levels for boundary locations were no different than those at distant stations. The average annual dose measured by the Environmental Science and Research Foundation during 1996 was 123 mrem for distant locations and 124 mrem for boundary community locations. The corresponding 5-yr averages measured were 127 mrem for the distant group and 125 mrem for the boundary group. These differences are well within the range of normal variation.

The offsite population could receive a radiation dose as a result of radiological conditions directly attributable to INEEL operations. The dose associated with radiological emissions is assessed annually to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants. The effective annual dose equivalent to the maximally exposed individual resulting from radionuclide emissions from INEEL facilities during 1995 and 1996 has been estimated at 0.018 mrem and 0.031 mrem, respectively (DOE-ID 1996, 1997b). These doses are well below both the Environmental Protection Agency (EPA) dose limit (10 mrem/yr) and the dose received from background sources (about 360 mrem/yr).

An estimate of the collective dose to the population surrounding INEEL as a result of air emissions from all facilities that were expected to become operational before June 1, 1995, has been completed (DOE 1995). The annual collective dose to the surrounding population, based on 1990 U.S. Census Bureau data, was estimated at 0.3 person-rem. This dose applies to a total population of approximately 120,000 people, resulting in an average individual dose of less than 0.003 mrem. For comparison, this population receives an annual collective dose from background sources of approximately 43,000 person-rem. The *Idaho High-Level Waste* (HLW) *& Facilities Disposition Draft Environmental Impact Statement* (EIS) revised the population dose in 1999 and estimated approximately 0.09 person-rem/yr (DOE-ID 1999a).

B-5. HYDROLOGY

B-5.1 Surface Water

Most of the INEEL and all of INTEC is in the Pioneer Basin, which is a closed topographic depression on the Snake River Plain that receives intermittent runoff from the Big Lost River, Little Lost River, and Birch Creek. The largest stream, the Big Lost River, flows southeast from Mackay Dam, past Arco, Idaho, and onto the Snake River Plain and enters the INEEL near the southern boundary. The Big Lost River is the principle surface water feature on the INEEL and the only stream with potential impacts to the TFF. The only other naturally occurring stream on the INEEL site is Birch Creek, which enters from the north. This stream is usually dry, except during heavy spring runoff when water may flow onto the INEEL site. The Little Lost River approaches the INEEL from the northwest, through Howe, and ends in a playa just off the INEEL. Research and further information on the surface water features and resources of the INEEL site are provided by Lamke (1969), Carrigan (1972), Tullis and Koslow (1983), and Bennett (1990).

The Big Lost River is the most important element affecting the surface water hydrology of INTEC (see Figure B-6). The northwest boundary of INTEC is closest to the Big Lost River channel, at approximately 200 ft (61 m). Stream flow measurements show an average discharge of 211,000 acre · ft/yr (260 E+08 m^3/yr) below Mackay Dam. The largest recorded annual flow for the entire period of record occurred in 1984 and amounted to 476,000 acre · ft/yr (587 E+08 m^3/yr), also measured below Mackay Dam. The second largest annual flow occurred in 1965 and amounted to roughly three-quarters of the 1984 record. Stream flows are often depleted before reaching the INEEL by irrigation

pre-decisional

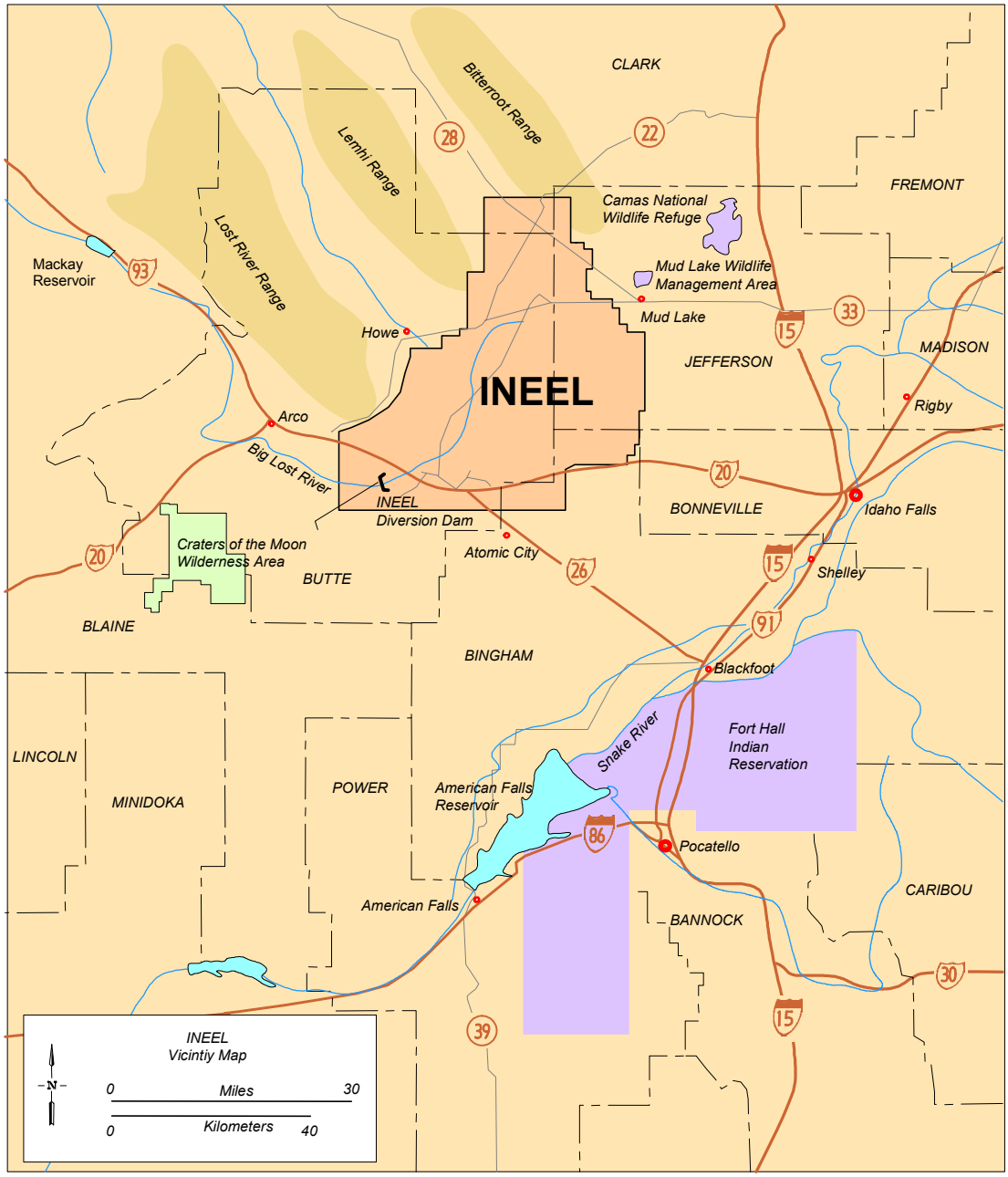

Figure B-6. Surface water features of the INEEL and surrounding vicinity.

diversions and infiltration losses along the river. When flow in the river reaches the INEEL, it is either diverted to the flood diversion facility (FDF) or it flows northward across the INEEL in a shallow, gravel-filled channel to its terminus in the Big Lost River playas. At the playas, it is lost to evaporation and infiltration and recharges the SRPA. For monthly discharge rates at Lincoln Boulevard near the INTEC see Table B-5.

B-5.1.1 Mackay Dam

Mackay Dam, located about 45-mi (48-km) upstream from the INEEL, impounds water from the Big Lost River for the Big Lost River Irrigation District. This is an earthfill dam that is 1,430 long by 79-ft (433 by 24-m) high. The dam was completed in 1917 and has a storage capacity of 44,500 acre · ft (5.0E+7 m^3) and surface area of 1,241 acres (502 ha) at a water surface elevation of 6,066.5 ft (1,849 m) (see Table B-6). An ungated overflow spillway with a weir length of 75 ft (23 m) at elevation (6,066.5 ft [1,849 m] mean sea level [MSL]) is located near the west abutment of the dam. The spillway is designed for a discharge of 3,250 cfs with 4 ft (1.2 m) of freeboard on the dam. The outlet works are also located near the west abutment and extend through the embankment and under the spillway to form an outlet channel. The outlet works consist of five motor-operated slide gates measuring 4 × 8 ft (1.2 × 1.4 m), mounted in an upstream control tower. The arched-roof outlet tunnel measures 10 × 10 ft (3 × 3 m), and reaches 500-ft (152-m) downstream into a 10-ft (3-m) diameter steel pipe, which extends to the outlet. The pipe branches into six 4-ft (1.2-m) diameter pipes emptying into a stilling basin at the toe of the dam. The combined discharge capacity of the outlet and spillway is less than 10,000 cfs. Water from the Big Lost River is impounded for the irrigation of approximately 57,500 acres (23,300 ha) of land downstream from the reservoir and for recreational opportunities. Another 10,200 acres (4,130 ha) of land upstream from the reservoir are irrigated with natural flow from the Big Lost River (INEEL 1999a).

B-5.1.2 INEEL FDF

The FDF includes a diversion dam, dikes, and spreading areas located about 10-mi (20-km) upstream from INTEC. The FDF was constructed in 1958 and enlarged in 1984 to reduce the threat of flood on the INEEL from the Big Lost River. The FDF controls or divides the flow in the Big Lost River between the spreading areas to the south and the playas to the north where the water can be temporarily stored until it infiltrates the ground and, thus, avoids flood-size flows past the INTEC and other INEEL facilities. The FDF has an elevation between 5,030 and 5,064.7 ft (1,530 and 1,543.7 m) MSL; the INTEC lies at approximately 4,917 ft (1,499 m) MSL, and the playas located about 18-mi (29-km) downstream from INTEC lie between 4,780 and 4,790 ft (1,457 and 1,460 m) MSL.

The FDF's diversion dam consists of a earthen diversion dam and headgate that diverts water from the main channel, through a connecting channel, and onto a series of four natural depressions, called spreading areas. Flow in the diversion channel is uncontrolled at discharges that exceed the capacity of the culverts. The diversion channel is capable of carrying 7,200 cfs (2.0E+02 m^3/s) from the Big Lost River channel into the spreading areas. Two low swales located southwest of the main channel will carry an additional 2,100 cfs (59 m^3/s) for a combined diversion capacity of 9,300 cfs (860 m^3/s). The capacity of the spreading areas is about 58,000 acre · ft (7.2E+07 m^3) at an elevation of 5,050 ft (1,540 m) MSL. An overflow weir in Spreading Area D allows water to drain southwest, off the INEEL.

Runoff from the Big Lost River has never been sufficient to exceed the capacity of the spreading areas and overflow the weir. Gates placed on two 6-ft (30 m^3/s) diameter corrugated steel culverts control flow downstream onto the INEEL. At full capacity the culverts are capable of handling up to 900 cfs of flow through the diversion dam. As stated above, there are no users of the surface water that reaches the INEEL (INEEL 1999a).

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Table B-5. Monthly discharge of the Big Lost River at Lincoln Boulevard near the INTEC.

Year	Jan (ft^3)	Feb (ft^3)	Mar (ft^3)	Apr (ft^3)	May (ft^3)	Jun (ft^3)	Jul (ft^3)	Aug (ft^3)	Sept (ft^3)	Oct (ft^3)	Nov (ft^3)	Dec (ft^3)	Annual (ft^3)
1965	0	0	2,380	10,300	15,400	29,600	31,100	16,900	10,900	0	0	0	116,580
1966	0	0	0	3,660	981	0	0	0	0	0	0	0	4,641
1967	0	0	0	0	2,030	20,180	18,376	4,400	9,050	8,740	0	0	62,776
1968	0	0	2,280	3,390	16	524	0	1,053	1,130	3,290	4,500	0	16,183
1969	0	0	0	3,960	33,000	33,500	21,800	4,780	9,840	6,710	3,290	0	116,880
1970	0	0	501	1,650	793	13,800	17,700	1,510	6,080	5,280	4,750	8	52,072
1971	0	0	0	10,600	12,300	17,200	20,800	7,760	13,400	14,400	13,100	0	109,560
1972	0	0	1,540	4,920	504	1,710	861	84	2,990	3,520	3,099	0	19,228
1973	0	0	0	2,830	405	0	0	0	0	0	0	0	3,235
1974	0	0	3,240	5,520	6,940	16,200	9,390	1,170	1,160	3,760	4,200	0	51,580
1975	0	0	0	3,180	12,000	12,100	18,700	3,560	6,520	8,210	7,990	0	72,260
1976	0	0	333	1,450	1,660	1,120	0	0	300	620	1,100	76	6,659
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	1,140	0	0	0	0	0	1,140
1981	0	0	0	1,300	5,092	7,560	0	0	0	0	0	0	13,952
1982	0	0	0	5,930	17,200	13,400	15,100	4,820	8,190	10,500	5,740	600	81,480
1983	600	600	900	12,800	15,800	18,900	18,200	9,780	7,320	6,200	5,660	1,200	97,960
1984	1,200	1,200	1,200	2,200	2,230	4,550	3,950	5,790	5,140	5,980	8,710	2,120	44,270
1985	3	0	0	7,170	6,430	0	0	0	9,950	10,707	1,275	0	35,535
1986	0	96	537	8,370	14,825	20,315	2,900	1,016	14,753	8,220	1,190	2	72,224
1987	0	0	531	491	0	0	0	0	0	0	0	0	1,022
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	6	0	0	0	0	0	0	0	0	0	0	6
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	5,116	0	0	0	0	0	0	5,116
1994	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Monthly discharge (ft^3) value for 1965-88 from Bennett 1990, *Streamflow Losses and Groundwater Level Changes Along the Big Lost River at the Idaho National Engineering Laboratory, Idaho*. United States Geological Survey (USGS) Water-Resources Investigations Report 90-4067. Data from 1989-94 from United States Geological Survey printout.

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Table B-6. Mackay Dam and INEEL diversion dam and reservoir characteristics.

Characteristic	Mackay Dam	INEEL Diversion Dam
Dam crest elevation (ft mean sea level [MSL])	6,076.0	5,064.7
Dam crest length (ft)	1,430	500
Dam height (ft)	79	22
Spillway	Ungated overflow crest, 75-ft long	none
Spillway crest elevation (ft MSL)	6,066.5	not applicable
Gate centerline elevation (ft MSL)	6,036.6 (upper) 6,007.8 (lower)	5,045.6
Dam base elevation (ft MSL)	5,997.0	5,042.6
Spillway maximum capacity (cfs)	6,588	NA
Gate maximum capacity (cfs)	2,960	1,121
Reservoir capacity[a] (acre · ft)	55,091 · 6,076.0 44,500 · 6,066.5 8,750 · 6,030.0 500 · 6,010.0	18,200 · 5,040.0 58,000 · 5,050.0

Source: Koslow and Van Haaften 1986; INEEL 1999a.

a. It has been estimated that Mackay Reservoir has lost 22% of its mid- and late-season irrigation capacity from sedimentation of the reservoir. Reservoir capacity given for the INEEL diversion dam is for the spreading areas; no water is held immediately behind the diversion dam.

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B-5.2 Floods

A study of recorded discharge data from several USGS streamflow stations along the Big Lost River upstream of the INEEL suggests a history of low-magnitude floods. Flooding in the basin is associated with peak flows during the snowmelt season and occasional flooding caused by ice jams in the stream channel. Big Lost River flows seem to be attenuated from the gravels, deep alluvium, and permeable basalt found in the channel bed. These streamflow losses combined with controlled streamflow, diversion canals, and irrigation use impact the natural flood peaks significantly. Downstream on the INEEL, the local semi-arid climate, relief, and geology combine to regulate local runoff. Local flooding in the past has been associated with unseasonably warm temperatures and rain on frozen ground as the following local flood history describes (INEEL 1999a).

B-5.2.1 Flooding in 1965

A record snowpack occurred in the Big Lost River basin in the winter of 1964, and the maximum runoff occurred in late June. The Mackay Reservoir was full, and most of the runoff was passed down to the basin and through the FDF on the INEEL. During the flood peak, June 29, 1965, approximately 1,800 cfs (51 m^3/s) were diverted to the spreading areas from a peak flow of 2,215 cfs (62.72 m^3/s). The Big Lost River overflowed its banks above Arco through most of June. On the INEEL, the flood was controlled by the FDF and by the storage and infiltration in the river channels, playas, and sinks. Even though the water did not reach the end of the Big Lost River channel at Birch Creek, this flood is significant because it exhibited the largest crest and water volume to be discharged onto the INEEL in 65 yr of record; yet, caused no damage to INEEL facilities.

B-5.2.2 Flooding in 1984

High streamflows in the Big Lost River and a severe cold spell during the winter of 1983 to 1984 caused ice jams that imposed a danger of localized flooding. Ice buildup in Spreading Area A resulted in waters backing up in the diversion channel and ultimately threatening to overtop Dike 1. The high streamflows in 1983 and 1984 were largely the result of the October 28, 1983, Borah Peak earthquake. The earthquake created new springs upstream of Mackay Reservoir, which increased the inflows to the reservoir significantly. Outflows from the reservoir were also increased to reduce the storage behind the dam. In response to this flood threat, upgrades to the diversion area were made to provide additional flood control, increasing the diversion channel flow capacity of 2,500 cfs (71 m^3/s) to over 9,000 cfs (300 m^3/s). Downstream INEEL facilities were not threatened or damaged by the accumulation of ice in the diversion channel. Generally during the winter months there is no flow in the Big Lost River downstream on the INEEL. If flow occurs it is diverted by the FDF to avoid the accumulation of ice in the main channel, which reduces the possibility of flooding downstream. In review of the historical information, no flooding or inundation from storms or runoff has caused flooding of the INEEL INTEC area.

B-5.2.3 Potential Flooding Considerations

As elaborated in following sections, the bounding flood scenario for the TFF is the overtopping failure of the Mackay Dam from a general storm probable maximum flood (PMF) (INEEL 1999a). The TFF site elevation is near or at the extent of floodwaters 4,917 ft (1,498 m) MSL predicted for this hypothetical dam failure scenario.

B-5.2.4 PMF on Streams and Rivers

The PMF represents the hypothetical flood that is considered to be the most severe flood event reasonably possible, based on hydro-meteorological application of maximum precipitation and other hydrologic factors. Either an unusually severe storm or some catastrophic event, such as a dam failure, may cause the PMF. For conservatism in safety and design, a PMF-induced overtopping failure of the Mackay Dam caused by an extreme precipitation event, the general storm probable maximum precipitation (PMP), is the bounding scenario used for INEEL facilities. Figure B-7 represents the PMF hydrograph and Figure B-8 is the inundation map for the PMF-induced failure of the Mackay Dam. Table B-7 provides information on the peak water surface elevation, peak flow, water velocity, and time of arrival at several downstream locations for this dam failure scenario. The following discussion was taken from the *Three Mile Island–2 Safety Analysis Report* (INEEL 1999b), which is applicable to the assessment of the TFF maximum flood.

B-5.2.5 Probable Maximum Precipitation and Flood

The general storm PMP for the drainage basin above Mackay Dam resulted from a 48-hr general storm in June, preceded three days by an antecedent storm with a magnitude of 40% of the 48-hr storm. This scenario provides for no flow losses to the ground to be conservative and represents situations in which the ground may be frozen or fully saturated. The peak flow for the PMF is 82,100 cfs, occurring 154 hr after the beginning of the storm. The PMF estimate falls within the 50,000 to 200,000 cfs Myers envelope curve used by the U.S. Army Corps of Engineers. The PMF peak flow is almost 20 times higher than the highest flow of 4,420 cfs recorded at Howell Ranch, a USGS station located approximately 17-mi (27 km) northwest of the dam. The PMF is based on the maximum potential for critical hydro-meteorological conditions to occur; not on probabilities or historical flood frequencies.

B-5.2.6 Precipitation Losses

The topography and drainage characteristics along the river change as it leaves the mountains at Arco. Below this point, the area is a low, flat plain with basalt bedrock. The drainage from most of the area in the Pioneer Basin is integrated with the Big Lost River. Locally, some depressions in

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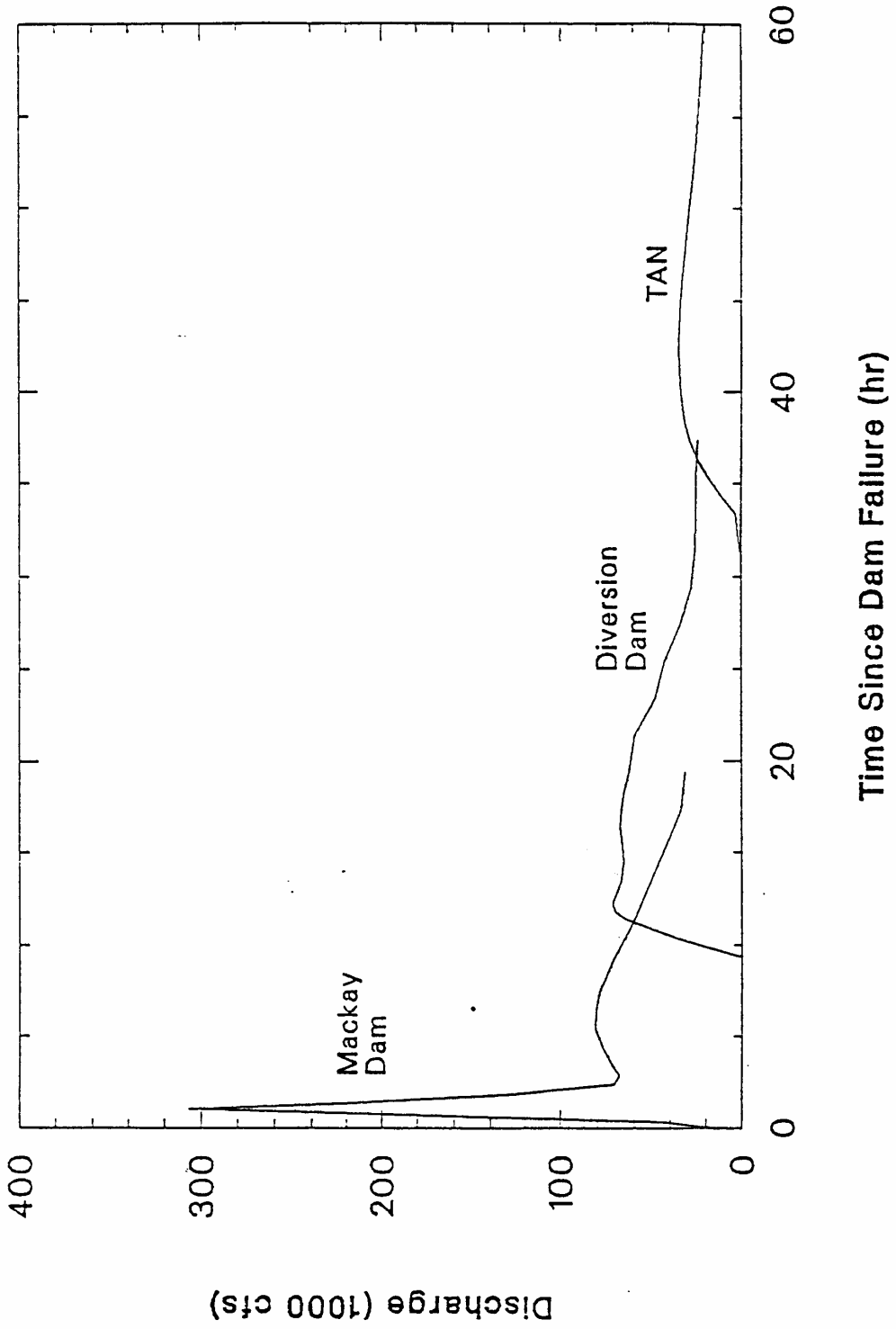

Figure B-7. Probable maximum flood–hydrograph from the Three Mile Island-2 Safety Analysis Report (INEEL 1999b).

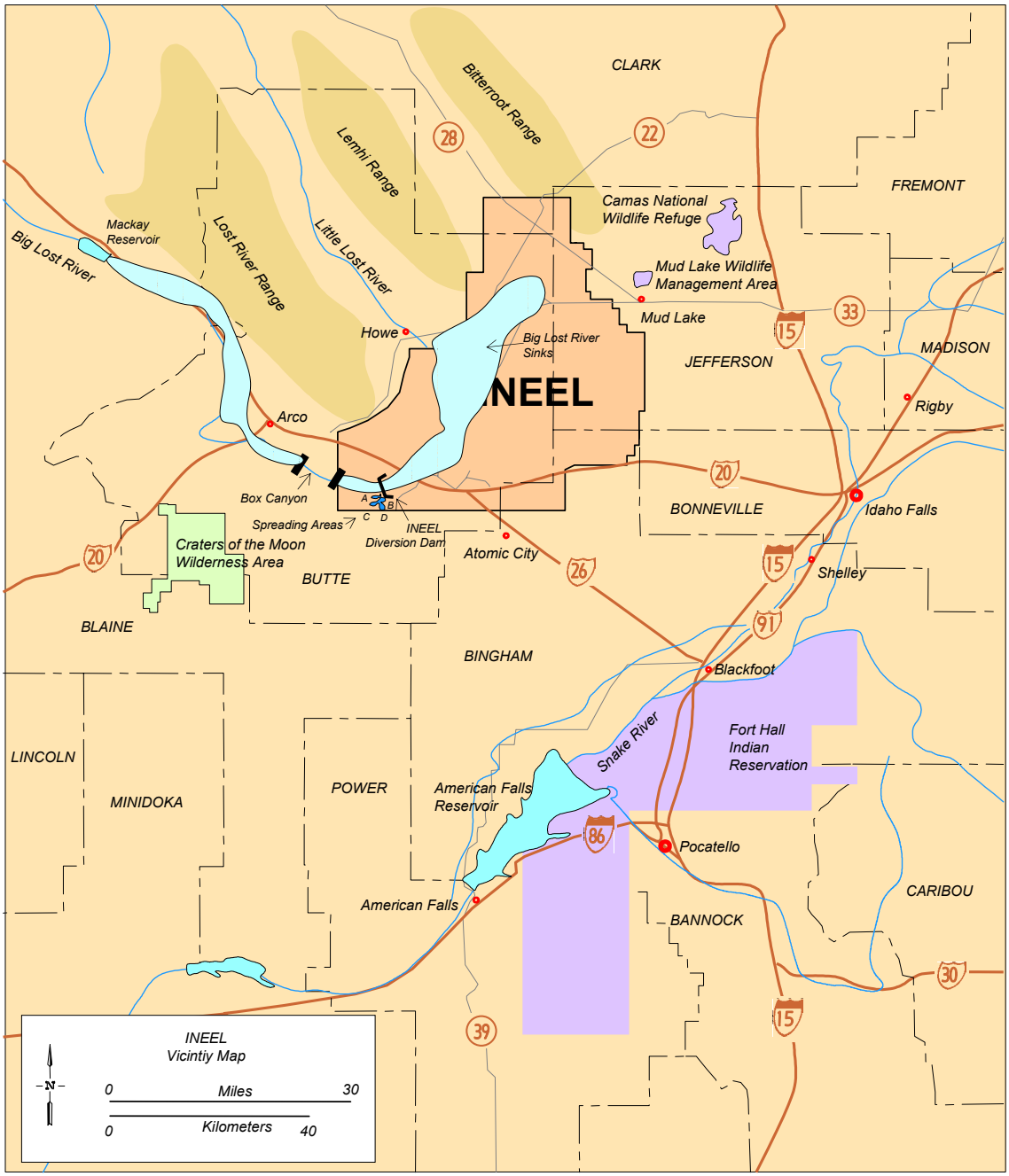

Figure B-8. Probable maximum flood–INEEL inundation map (INEEL 1999b).

Table B-7. Results of PMF-induced overtopping failure of Mackay Dam.

Location (approximate elevation, ft mean sea level [MSL])	Streambed elevation (ft MSL)	Peak water surface elevation (ft MSL)	Peak flood flow (cfs)	Peak water velocity (ft/s)	Time of wave arrival (hr)
Mackay Dam (6076)	5997	6078	306,700	8.5	0.0
Arco (5310-5410)	5309	5319	147,720	5.6	6.7
INEEL Diversion Dam (5065)	5043	5073	71,850	1.0	10.0
Central Facilities Area (4928-4940)	4935	4942	67,830	3.4	12.8
Test Reactor Area (4920-4925)	4919	4924	67,170	2.8	13.2
Idaho Nuclear Technology and Engineering Center (4914-4930)	4911	4916	66,830	2.7	13.5
Naval Reactor Facility (4845-4850)	4846	4851	61,620	1.9	16.4
Test Area North (4780-4795)	4778	4786	34,810	1.1	34.5

Source: Koslow and Van Haaften 1986.

Total flow to INEEL diversion spreading areas: 27,460 acre · ft.

Total Mackay Reservoir release: 142,330 acre · ft.

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the basalt receives intermittent runoff. However, there is seldom enough precipitation in this area to exceed the infiltration capacity of the soil to create intermittent streams to the Big Lost River.

B-5.2.7 Runoff Model

The combined Big Lost River Basin and Pioneer Basin range in elevation from 4,784 to over 12,600 ft (1,458 to more than 3,840 m) MSL. Thus, this area has over 7,546 ft (2,300 m) of relief, resulting in large differences in temperature and climate at any given time. The lowland in the Pioneer Basin is subjected to periods of warm wind, rain, and snowmelt during the winter months. These conditions cause runoff and minor flooding in the lower basins during regional storms and substantially increase the snowpack in the uplands. The largest documented runoff periods in the lower parts of the basins have occurred in January, February, or March; the maximum runoff from the highlands usually occurs in May or June. Generally, frost leaves the ground in the Pioneer Basin and the valley floors of the mountain basins in March or April; the permeable soils and gravels can then accept surface water by infiltration before the bulk of the snow pack starts to melt. Most surface water reaching the Pioneer Basin from the tributary drainage basins eventually infiltrates beneath the soil and rock to the groundwater reservoir. The remainder is lost through evaporation.

B-5.2.8 Probable Maximum Flood Flow

The spillway of Mackay Dam is not adequate to pass the PMP safely; therefore, overtopping and subsequent breaching of the dam resulting from this PMP storm were analyzed. During this overtopping failure, the inflow is sufficient to

raise the water surface above 6,077 ft (1,852 m) MSL, 1 ft (0.3 m) above the crest of the dam. A trapezoidal breach was assumed to develop over a 1-hr period and extend to the base of the dam. The computer program DAMBRK, developed by the National Weather Service, was used in the flood-routing analysis.

The peak flow resulting from the PMP-induced overtopping failure is 306,700 cfs in the reach immediately downstream of the Mackay Dam. This peak flow attenuates to 71,850 cfs at the INEEL diversion dam and to 66,830 cfs at INTEC. The flood wave reaches the INEEL diversion dam in 10 hr. Water velocities are approximately 1 to 3 ft/s downstream on the INEEL. The computer program DAMBRK identified the water levels at specified locations for the PMF-induced overtopping failure. The wind activity at the INEEL coincident with the largest projected flood crest could not produce waves that would exceed 0.5 ft (0.2 m) because of the shallow depth of water surrounding most INTEC buildings (Lockheed Idaho Technologies Company 1994). Thus, the static and dynamic effects of wave activity would be negligible.

B-5.2.9 Potential Dam Failures

Mackay Dam is classified as a high-hazard dam by the State of Idaho with reference to the U.S. Army Corps of Engineers guidelines for safety inspection of dams. This high-hazard classification is based on the concentration of people and property downstream, the size of the dam, and its storage capacity, not on any aspect of the dam's current condition or operation.

Mackay Dam is located in a region of historical seismicity as evidenced by the 1983 Borah Peak earthquake. The performance of the dam during this earthquake demonstrated the stability of the embankment during moderate ground motion. However, the Mackay Dam was built without any seismic design criteria; therefore, a seismically induced dam failure has been analyzed to determine potential impacts to the INEEL. This analysis assumed a postulated seismic failure of Mackay Dam during an inflow to the reservoir equal to the 25-yr recurrence interval flood (peak flow 4,030 cfs). Because a seismic event may potentially disrupt a significant part of the dam's structure, the breech was assumed trapezoidal, extending to the bottom of the structure at 5,997 ft MSL and developing over a 1-hr period. The peak flow from the seismic dam failure in the reach immediately downstream of the dam is 107,480 cfs. This peak flow attenuates to 45,410 cfs at the INEEL diversion dam and to 39,080 cfs at the INTEC. The leading edge of the wave reaches the INEEL diversion dam in approximately 12 hr., with average water velocities on the INEEL from 1 to 3 ft/sec.

Other dam failure permutations examined include two hydraulic (piping) failures concurrent with a 100-yr and 500-yr inflow floods to the reservoir. The INEEL diversion dam would be overtopped by the floodwaters released from the failure of Mackay Dam. This overtopping of the INEEL diversion dam will contribute to the flooding downstream on the INEEL. The DAMBRK analysis assumes that the INEEL diversion dam begins to fail when floodwaters reach 5,065 ft (1,544 m) MSL, an overtopping depth of 0.3 ft (9 cm). Because of the small size of this dam, the breach is assumed to be fully developed after 0.1 hr, an essentially instantaneous failure.

The flood from dam failure would initially travel down a valley between basalt flows. The initial velocity would be high near the failure, but the average velocity would decrease to approximately 1.0 ft/s (0.31 m/s) near the FDF. Water entering the FDF from this flood is much less than the actual capacity of the spreading area (Koslow and Van Haaften 1986). Water that bypasses the FDF would continue to spread across the floodplain and have a peak water velocity of 2.7 ft/s at INTEC.

The worst evaluated flooding condition at the INTEC results from the failure of the Mackay Dam from the PMP storm. This would result in flood water within the INTEC controlled area up to 4,917 ft (1,499 m). The existing ground elevation of the INTEC TFF site varies between 4,914 and 4,917 ft (1,497.8 and 1,499 m) MSL

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with the majority of the tanks located in an area with an elevation of 4,914 ft (1,499 m).[c]

B-5.3 Perched Water

There are several perched water zones underlying the INTEC facility, and information and data about these zones were used in the development of source term modeling for the INEEL groundwater. Perched water zones can be divided into two categories: an upper perched water zone and a lower perched water zone. The upper basalt perched water zone (see Figure B-9) was initially discovered in the late 1950s where wells USGS-50 and USGS-52 encountered perched water at 126 and 174 ft (38.4 and 53.8 m) BGL, respectively. Based on the presence of radioactive and chemical contaminants, the occurrence of this perched water was attributed to operational practices. Since then, numerous monitoring wells have been installed in the upper perched water zone to identify the source of recharge, delineate the perched water bodies, and determine the nature and extent of contamination.

A lower perched water zone was also identified in the basalt at depths between 340 and 400 ft (104 and 122 m) BGL (Robertson et al. 1974). This zone was first discovered in 1956 while drilling Well USGS-40 when perched water was encountered at a depth of 348 ft (106 m). An analysis of this perched water detected abnormally high total dissolved solids (303 mg/L), sodium (25 mg/L), and chloride (81 mg/L) indicating the water is of waste origin (Olmsted 1962). According to Robertson et al. (1974), this was a reasonable level for the perched groundwater because of the presence of a clay bed "aquitard" at 370 ft (113 m) BGL. In the late 1950s, only wells drilled in the northern INTEC encountered the lower perched groundwater zone. Since 1984, a lower perched groundwater zone has also formed in the southern INTEC from disposal of process waste through the percolation ponds. The location of this lower perched water zone is indicated by Well MW-17 and borehole neutron logs from Well USGS-51.

Stratigraphy controls the hydrogeologic characteristics of the subsurface at the INTEC, particularly in the formation and movement of perched groundwater. The formation of perched groundwater can be attributed to lithologic features contributing to contrasts in the vertical hydraulic conductivity of basalt layers and sedimentary interbeds in the unsaturated zone. Cecil et al. (1991) attributed four lithologic features to the formation of perched groundwater at the INTEC. Perched groundwater can form where (a) a sedimentary interbed with a reduced vertical hydraulic conductivity underlies a more conductive basalt layer, (b) altered baked zones between two basalt flows reduce the hydraulic conductivity, (c) the presence of dense unfractured basalt having low vertical hydraulic conductivity, and (d) sedimentary and chemical filling of fractures near the upper contact of a basalt flow reduce the vertical hydraulic conductivity.

Water movement in the basalt units located in the unsaturated zone is poorly understood. The presence of perched water at the surficial sediment-basalt contact indicates how water moves into the underlying fractured basalts. Water in a partially saturated medium is held under negative pressure or tension. This capillary tension prevents water from moving from a region with small pore spaces, such as the sediment interbeds, into a region of larger pore spaces, such as the fractured basalts, until the tension is nearly reduced to zero pressure or, in other words, reaches saturation in the overlying sediment interbeds. As a result, water movement into the fractured basalts is likely dominated by fracture density (Maheras et al. 1994). Fracture spacing measurements documented in Knutson et al. (1992) indicate that near perimeter zones of basalt flows, the spacing between fracture decreases to 0.82 ft (0.25 m).

In modeling studies conducted by Maheras et al. (1994) for the RWMC area, water movement through the fractured basalt is assumed to be rapid, on the order of 98 ft (30 m) per month.

c. Personal communication from Roemer, E. Kirk, Portage Environmental, Inc., to Randy Lee, Senior GIS Analyst at Idaho National Environmental and Engineering Laboratory, "GPS Mapping of the INTEC Facility," 2000.

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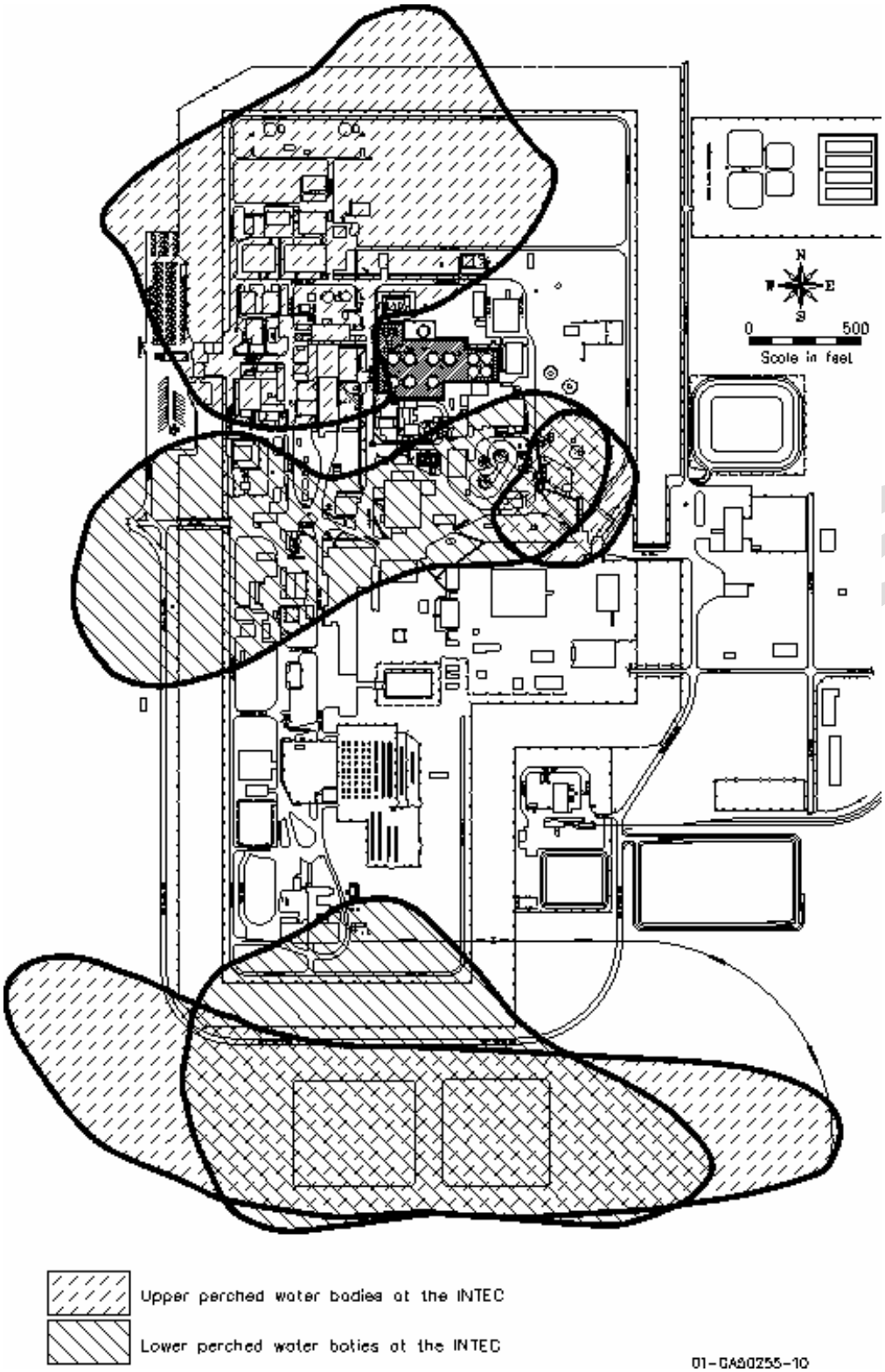

Figure B-9. Upper and lower perched groundwater zones at the INEEL.

Conceptually, the model for the RWMC area excluded the fractured basalt and only included the sediment interbeds stacked together so that they were in direct contact with each other. The fractured basalt was assumed to have negligible water travel times and was not included in the simulations.

Modeling conducted for the Comprehensive Remedial Investigation and Feasibility Study (RI/FS) for the Idaho Chemical Processing Plant OU 3-13 at the INEEL – Part A, RI/BRA Report (also known as the Waste Area Group [WAG] 3 RI/FS) assumed that the basalt can be treated as an anisotropic "single porosity" media where the matrix is neglected and only the fractures are considered for the transport of water (Rodriguez et al. 1997). For this modeling approach, a horizontal and vertical fracture permeability of 90,000 m · darcy (D) and 300 m · D, respectively, and an effective porosity of 5% was applied. Additional information on perched water zones at the INEEL is presented by Rightmire and Lewis (1987), Cecil et al. (1991, 1992), Magnuson and McElroy (1993), and McElroy (1993).

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B-5.3.1 Upper Perched Zone

Based on the perched water data, it appears that the upper perched groundwater bodies are formed by the relatively low vertical hydraulic conductivity in the sedimentary interbeds. Of particular importance to the formation of perched groundwater are the CD, D, and DE3 interbeds. Figure B-9, shows the location of the upper basalt perched water zone that occurs between depths of 100 to 190 ft (31 and 58 m). The location and extent of the upper perched water zones are dependent not only on the stratigraphy but the location of the recharge source. It appears that water sources vary from the northern to the southern portions of the INTEC facility. Consequently, each area will be discussed in detail in the following sections.

B-5.3.2 Northern INTEC

Two perched groundwater bodies have been identified in the northern INTEC. The upper perched groundwater body is present above the CD and D interbeds, and the lower perched groundwater body has been identified on the DE3 interbed. According to the lithology, the CD interbed occurs at depths between 113 and 119 ft (34.4 and 36.3 m) BGL, the D interbed occurs at depths between 128 and 135 ft (39.2 and 41.1 m) BGL, and the DE3 interbed occurs at depths between 163 and 170 ft (49.7 and 52 m) BGL. Based on available information, it appears that the perched groundwater between the CD and D interbeds is continuous over much of the northern INTEC as these interbeds are only separated by 9 ft (3 m).

Twenty-three monitoring wells (including multiple completion wells) have been installed in the northern INTEC to monitor the upper perched groundwater (i.e., groundwater that occurs less than 190 ft (58 m) BGL. Only a few of these wells still exist. In addition to the monitoring wells, Well MW-4 is completed at the bottom of the D interbed and Well MW-10 is completed in a fracture zone associated with the BC interbed. Historically, both of these wells have been dry.

The extent of the upper basalt perched groundwater body is provided in Figure B-9. Water-level elevations range from 4,797.3 to 4,845.3 ft (1,462.2 to 1,476.8 m) above mean sea level (AMSL) and represent the average water-table level throughout the monitoring period. The extent of the perched water above the CD and D interbeds is also illustrated in this figure. Perched groundwater is not known to occur above these interbeds outside the areas illustrated on the map. Where the perched water bodies overlap (i.e., in the vicinity of wells CPP-33-4, CPP-33-1, MW-5), the entire region between the CD and D interbeds is likely to be saturated. Otherwise, perched groundwater is only present above the associated interbed.

Based on the water-table configuration, it appears that multiple water sources are providing recharge to the upper basalt perched water body in the northern INTEC. Seepage from the Big Lost River is a potential source of water in the northern INTEC area. The sewage treatment ponds, located east of the facility, provide approximately 1.25E+06 gal (4.73E+06 L) per month of recharge to this perched water body. This recharge has resulted in a water-table elevation of 4,845 ft

(1,477 m) AMSL in the well (CPP-MON-P-024) completed near the sewage treatment ponds. In the western portion of the perched water body and beneath the main portion of the facility, recharge has produced a maximum water-table elevation of 4,818 ft (1,468 m) in Well CPP-33-2. Between the eastern and western portions of the upper perched water body, the average groundwater elevation is 4,809.2 ft (1,465.8 m) in Well CPP-37-4. This water-table configuration indicates that separate sources of water are providing recharge to the eastern and western portions of the upper-most perched water body and that the sewage treatment ponds have minimal, if any, impact upon the western portion of this perched water body.

Occurring beneath the upper perched groundwater body, a deeper perched groundwater body has been identified at a depth of approximately 140 ft (43 m) BGL. This groundwater appears to be the result of the DE3 interbed, which occurs between 163 and 169 ft (49.7 and 51.5 m) BGL in the northern INTEC. Only three wells (MW-10, MW-12, and MW-20) are completed in this perched groundwater body. Based upon monitoring data, the water-table elevation within this perched water zone varies from 4,769 to 4,779 ft (1,454 to 1,457 m) AMSL.

B-5.3.3 Southern INTEC

The upper perched water bodies identified in the southern INTEC are also shown in Figure B-9. The largest perched water body is the result of discharge to the percolation ponds and monitored by wells PW-1 through PW-6. In the vicinity of CPP-603, six wells (MW-7, MW-9, and MW-13 through MW-16) were installed to monitor perched water on the upper interbed that is present between 110 and 130 ft (34 and 40 m) BGL. One triple completion well (MW-17) was installed to monitor for perched water on a deeper interbed occurring approximately 190 ft (58 m) BGL.

Wells PW-1 through PW-6 were installed adjacent to the percolation ponds to monitor the perched groundwater beneath the ponds. The hydrographs for these wells show similar fluctuation in the water level as observed for wells PW-1, PW-3, and PW-6 indicating these wells are effective in monitoring infiltration from the western percolation pond. The water-level fluctuation in Well PW-4 is opposite to the response observed in wells PW-1, PW-3, and PW-6, indicating this well monitors infiltration from the eastern percolation pond. The water-level fluctuations in wells PW-2 and PW-5 are fairly consistent and indicate that these wells are influenced by discharge to either pond.

Field aquifer tests were performed to determine the hydraulic conductivities for both basalt and sedimentary interbeds. Hydraulic conductivities determined in the field were fairly consistent, varying only over two orders of magnitude. Field hydraulic conductivities ranged from 0.11 to 8.3 ft/d (3.4 cm/d to 2.5 cm/d) with an average of 3.3 ft/d (1.0 m/d). Significant differences in hydraulic conductivities were not observed between tests performed on the basalt versus tests performed on sedimentary interbeds (i.e., interbeds CD, D, and DE2). The depths are approximately 110, 140, and 230 ft (34, 43, and 70 m) BGL. A complete discussion of the sample collection and laboratory data package is described in *Interim Data Results from the FY 93/94 Perched Ground Water Investigation* (1994).

The range of hydraulic conductivities determined from the field aquifer tests is within the range of hydraulic conductivities measured in the laboratory. The average hydraulic conductivity determined from the field tests is 3.3 ft/d (1.0 m/d) compared to an average of 1.96 ft/d (0.597 m/d) determined from the laboratory tests. Some of the difference between the two hydraulic conductivities may be attributed to the fact that the field tests measured horizontal hydraulic conductivity whereas the laboratory tests measured vertical hydraulic conductivity. Typically, horizontal hydraulic conductivities are higher than the corresponding vertical hydraulic conductivities.

Good correlation in the hydraulic conductivity values occurred from the boreholes where both field and laboratory measurements were performed. From the same zone in Well MW-4, the average hydraulic conductivity determined in the laboratory was 0.1 ft/d (3 cm/d) compared to the field determined value of 0.11 ft/day

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(3.4 cm/d). Similarly in Well MW-6, the hydraulic conductivity determined in the laboratory was 6.2 ft/d (1.9 m/d) compared to the field determined value of 3.7 ft/d (1.1 m/d). These two wells are the only locations where both field and laboratory measurements were performed.

B-5.3.4 Lower Basalt Perched Water Zone

A lower perched groundwater zone has been identified in the basalt between 320 and 420 ft (98 and 130 m) BGL. This zone was first discovered in 1956 while drilling Well USGS-40 when perched groundwater was encountered at a depth of 348 ft (106 m) (Robertson et al. 1974). Since then, groundwater has been encountered in this zone during the drilling of wells USGS-41, USGS-43, USGS-44, USGS-50, USGS-52, MW-1, MW-17, and MW-18. Borehole neutron logs ran in 1993 indicate perched water may still be present in this zone from wells USGS-40, USGS-43, USGS-46, USGS-51, and USGS-52.

Only four wells, which presently monitor water-level changes, are completed in the lower perched water zone. Wells MW-1, MW-18, and USGS-50 are completed in the northern portion of the facility, having encountered water at approximately 322, 407, and 383 ft (85, 107.5, and 101 m) BGL, respectively. In the southern portion of the facility, only Well MW-17 is completed in the lower perched water zone where water is encountered at a depth of approximately 315 ft (96.0 m) BGL. Based upon water quality information, the deep perched groundwater encountered by Well MW-17 is the result of discharge to the percolation ponds.

Similar to the upper basalt perched water zone, the lower perched water zone is thought to be formed by decreased permeability associated with sedimentary interbed layers. It appears that the lower perched groundwater has formed primarily on the DE8 interbed. The top of this interbed occurs beneath the INTEC at depths ranging from 383 to 426 ft (117 to 130 m) BGL. In the western portion of the facility, however, the DE6 interbed is responsible for creating perched groundwater associated with wells USGS-40 and USGS-43. It should be noted that these data contain a high degree of uncertainty, as they consist of a combination of original driller's logs (some dating back 40 yr), geophysical borehole logs, and monitoring wells that are completed in this zone.

As shown in Figure B-9, the lower perched water zone is probably not continuous beneath the entire facility and may actually consist of several individual perched water bodies. The north-south separation of the lower perched water bodies is based on the lack of perched groundwater (either through drilling or subsequent neutron logging) identified in wells USGS-42, USGS-45, USGS-47, USGS-48, and USGS-49. Recharge to the southern perched water body is from wastewater discharged to the percolation ponds. The source of recharge to the western portion of the northern perched water body is believed to be seepage from the Big Lost River.

Water levels in this lower perched water zone have been monitored since the early 1960s in Well USGS-50. Other than during the late 1960s and early 1970s, the water level in this well has been fairly consistent and generally ranged between 4,530 and 4,540 ft (1,381 and 1,384 m) AMSL. In the late 1960s and early 1970s, however, the water level increased by approximately 90 ft (30 m) in response to failure of the INTEC injection well. During this period, wastewater was discharged directly to the vadose zone from the INTEC injection well at a reported depth of 226 ft (68.9 m) BGL.

The presence of a deep perched groundwater zone beneath the percolation ponds is indicated by the borehole neutron response from wells USGS-51 and MW-17. Figure B-10 shows the natural gamma log, stratigraphy, and epithermal neutron logs ran in 1984, 1985, and 1986 for Well USGS-51. Deflections of the neutron log to the left indicate increases in moisture content. As shown in this figure, two zones illustrate significantly increasing moisture content since the percolation ponds were placed into service on February 1984. These two zones occur from 145 to 178 ft (44.2 to 54.3 m) and 274 to 332 ft (83.5 to 101 m) BGL.

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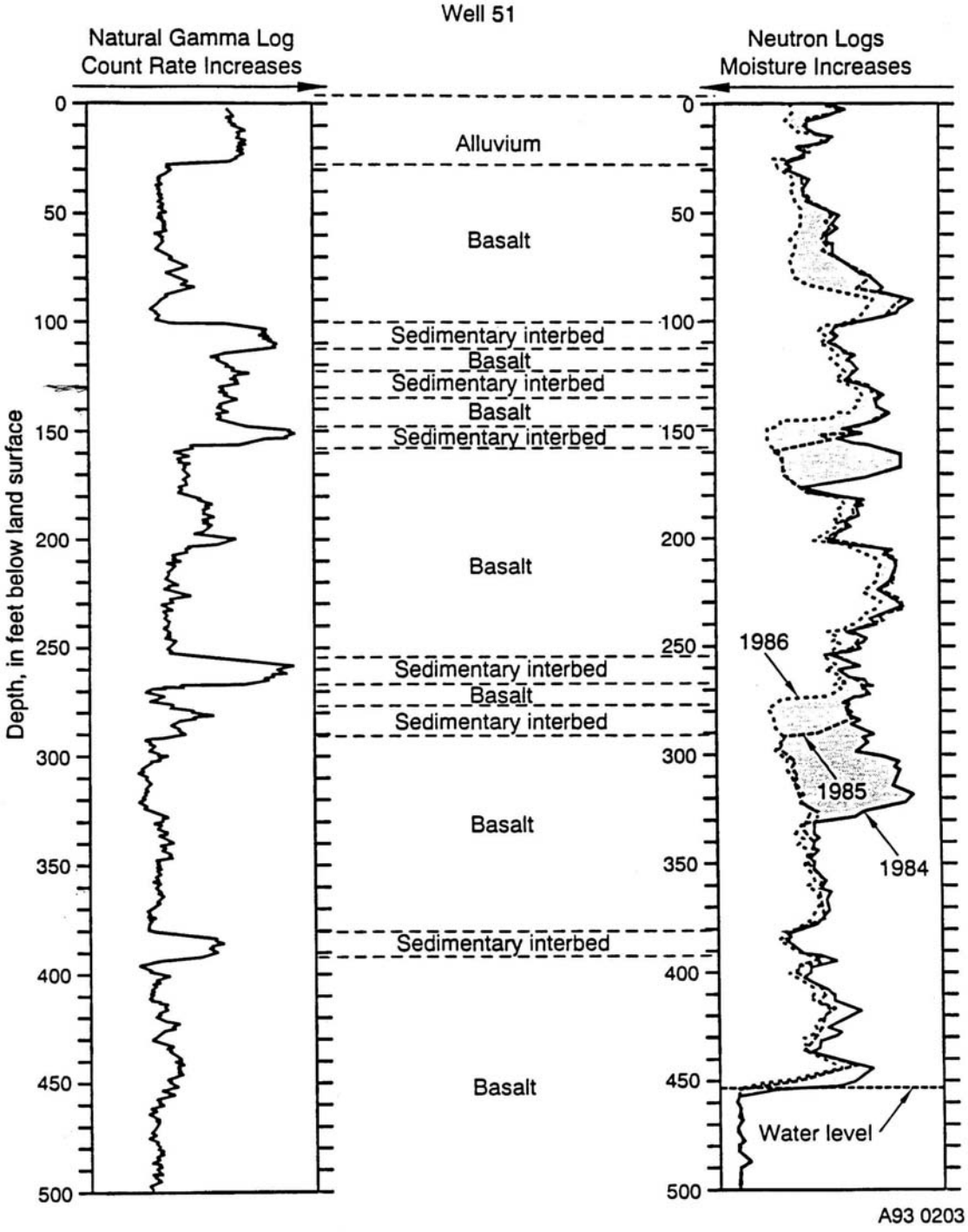

Figure B-10. Natural gammalog, stratigraphy, and epithermal neutron logs that ran in 1984, 1985, and 1986 for Well US65-51.

B-5.3.5 Regional Aquifer

The general direction of regional groundwater movement underlying the INEEL is to the south and southwest. The average slope of the water table is approximately 4 ft/mi. In the northern part of the INEEL, near Birch Creek valley, the water-table gradient is relatively low, sloping southward about 1 ft/mi (0.2 m/km) (Barraclough et al. 1967).

Groundwater in the SRPA generally occurs under unconfined conditions, but locally may be quasi-artesian or artesian (Nace et al. 1959). Layers of dense, massive basalt or sediments cause the quasi-artesian or artesian conditions as a result of their relatively low permeability. Nace et al. (1959) described quasi-artesian as the situation in which the groundwater level is first recognized in a borehole during drilling at a depth below the regional water table, and then the level rises significantly (5 to 50 ft [2 to 20 m]) to the level of the water table. This rise of the water level simulates artesian pressure, but the conditions are not truly artesian. Nace et al. (1959) also noted water levels in some wells in the SRPA respond to fluctuations in barometric pressure similar to wells in confined aquifers, indicating that tight zones in the basalt may impede pressure equalization. True artesian or flowing artesian conditions in the SRPA were identified at Rupert, in parts of the Mud Lake Basin, and north of the American Falls Reservoir (Nace et al. 1959).

Recharge to the aquifer is primarily by valley underflow from the mountains to the north and northeast of the plain and from infiltration of irrigation water. A small amount of recharge occurs directly from precipitation. Recharge to the aquifer within INEEL boundaries is primarily by underflow from the northeastern part of the plain and the Big Lost River (Bennett 1990). Significant amounts of recharge from the Big Lost River have caused water levels in some wells at the INEEL to rise as much as 6 ft (2 m) in a few months after high flows in the river (Barraclough et al. 1984). Locally, the direction of groundwater flow is temporarily changed by recharge from the Big Lost River (Bennett 1990).

The effective hydraulic conductivity of the basalt and interbedded sediments that compose the SRPA at and near the INEEL ranges from 1.0E−02 to 3.2E+4 ft/d (3.0E−03 to 9.8E+3 m/d). This six-order of magnitude range was estimated from single-well aquifer tests in 114 wells and is mainly attributed to the physical characteristics and distribution of basalt flows and dikes (Anderson et al. 1999). According to Anderson et al. (1999), the relative hydraulic conductivity distribution through a typical buried shield volcano in the Snake River Plain suggests that the conductivity of a single lava field is greatest in near-vent volcanic deposits composed of shelly pahoehoe and slab pahoehoe flows and bedded scoria, spatter, and ash. These near-vent deposits typically cover about 10 to 20% of the lava field. Hydraulic conductivity of basalt flows is least for thick, tube-fed pahoehoe flow and ponded flow inside the vent craters and topographic depressions.

Anderson et al. (1999) compared the relationship between the thickness of the basalt and sediment layers to hydraulic conductivity and concluded that stratigraphic intervals composed of thin basalt layers have more contacts, rubble zones, and cooling fractures, and, hence, greater hydraulic conductivity than intervals of equal thickness composed of thick layers of basalt.

Walker (1960), Ackerman (1991), and Anderson et al. (1999) present a detailed analysis of the geologic control related to hydraulic conductivity along with hydraulic testing results for the regional aquifer.

B-5.4 Infiltration

B-5.4.1 Rainfall

Natural recharge from precipitation is also available to support perched water bodies. Long-term average annual precipitation at the INEEL is 8.7 in. (22 cm) and pan evaporation is on the order of 43 in./yr (110 cm/yr). Nevertheless, water from snowmelt or heavy rains may infiltrate to a depth where it cannot be evaporated. Furthermore, many areas within the INTEC are impervious and precipitation runs off to drainage ditches. The ditches are unlined and a significant fraction of

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infiltration is likely to occur along the ditches. Estimates of net recharge from precipitation range from 1 to 4 in. (3 to 10 cm) (Miller et al. 1990), with 1.6 in./yr (4.1 cm/yr) being considered to be the best estimate for net infiltration to be used at the INTEC. Infiltration may actually be greater due to the impervious areas, drainage ditches, and infiltration ponds used to collect runoff. Using a net infiltration rate of 1.6 in./yr (4.1 cm/yr) and assuming the recharge area for the entire INTEC to be approximately 184 acres (74.5 ha) provides an estimate of 8 M · gal (30 M · L) of water available for recharge from natural precipitation. For the northern perched water bodies, approximately 3.8 M · gal (14.3 M · L) of recharge is available due to precipitation using an area of 87 acres (35 ha).

B-5.4.2 Artificial Sources

The INTEC uses approximately 2.1 M · gal (7.9 M · L) of water each day. Two raw water wells and one potable water well supply water. The water is used for process cooling, equipment cooling, steam production, process solutions, decontamination, fuel storage, basin makeup, chemical laboratory use, regeneration of ion exchange units, fire protection, and human uses. Piping systems external to facility buildings are either buried or enclosed in utility tunnels. The INTEC water systems that were considered relevant to the water inventory study included the raw water, fire water, treated (softened) water, demineralized water, steam condensate, landscape water, potable water, service waste (industrial wastewater), and sanitary waste systems. Criteria of low volume, secondary containment, distinct radiological or chemical signature, and close monitoring or visibility were used to eliminate the steam distribution system, high-level liquid waste (HLLW) process lines, and pipes used to distribute cooling water to the HLLW storage tanks in the TFF from leak testing.

The primary water systems at the INTEC include the raw water system, fire water system, water softeners (treated water system), and demineralizer (demineralized water system). The raw water system piping has an approximate length of 6,250 ft (1,910 m) and an average flow of 389 gal/min (1,480 L/min). Raw water is pumped from the aquifer from two production wells to the fire water storage tanks. The raw water feed tanks supply water to three distribution pumps. The fire water piping system has a length of 5 mi (8 km), with an average flow of 45 gal/min (200 L/min). This system, in addition to firefighting, is used for lawn watering, safety showers, cooling of waste tanks and sump pump bearings, and flushing radiation monitor bowls. The treated (softened) water system has a length of 4,000 ft (1,000 m) and an average flow of 900 gal/min (4,000 L/min). Treated water is used for chemical process makeup and in heat exchangers. The demineralized water system has a length of 4,200 ft (1,300 m) and an average flow of 1.5 gal/min (5.7 L/min). Demineralized water is used for process cooling, steam, and in fuel storage basins.

The steam condensate piping system has a length of 4,200 ft (1,300 m) and an average flow of 74 gal/min (280 L/min) between September and April. Primary steam use occurs between the months of September and March mainly because of seasonal demands such as heating and freeze protection. Most of the steam is condensed and recycled or routed to the service waste system. Approximately 10% of the steam is either released to the atmosphere or discharged to the ground.

The potable water system has a length of 2 mi (3 km) with an average flow of 61 gal/min (231 L/min). Potable water is supplied from two wells in the SRPA. Water is pumped to a storage tank, and three distribution pumps in building CPP-606 are used to supply potable water to INTEC facilities. The potable water system includes a chlorination system.

The service waste piping system has a length of 2.4 mi (3.9 km) and an average flow of 1,320 gal/min (5,000 L/min). Raw water, treated water, demineralized water, and steam condensates are discharged to the service waste system. Waste streams that might be contaminated with radioactive materials are monitored before discharge to the service waste system, and the water is diverted to a holding tank for processing in the process equipment waste evaporator, if contamination is detected. Water in the service

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waste system is discharged to two percolation ponds located on the south end of the facility.

The sanitary sewer piping system is 1.5-mi (2.4-km) long and has an average flow rate of 29 gal/min (110 L/min). Potable water and sanitary waste from INTEC facilities are discharged to the sanitary sewer system and gravity drained to lift stations, where the waste is pumped to the INTEC Sewage Treatment Plant. The waste is transferred to a series of treatment lagoons located at the northeast corner of the INTEC.

The seven landscape watering systems are all located in the northern INTEC and historically covered a total area of 1.5 acre (0.61 ha). Approximately 20,000 gal/d (75,700 L/d) from the raw water, fire water, and potable water systems have been used to maintain lawns and landscaping at the INTEC during the summer months. A total volume of 2.35 M · gal (8.90 M · L) was used to water INTEC lawns each year. Consumptive use was calculated to require 784,000 gal (2,967,400 L) per growing season. Subtracting the consumption and evapotranspiration from the supplied water yields a net volume of 1.57 M · gal (5.94 M · L) available for infiltration and recharge of the perched water bodies.

A summary of the amount of water available to recharge the perched water bodies at the INTEC is provided in Table B-8. Historically, approximately 720 M · gal/yr (2.73 billion L/yr) are known to be providing recharge at the INTEC. This does not include an additional 38.4 M · gal (1.45 B · L) that could be leaking through the facility piping undetected by the current metering system.

B-5.5 Water Resources

The SRPA, one of the largest and most productive groundwater resources in the United States, underlies the INEEL. The aquifer is listed as a Class I aquifer and was designated by the EPA as a sole source aquifer in 1991. Groundwater from this aquifer supplies essentially all drinking water consumed within the ESRP (DOE-ID 1999a).

The SRPA, which runs under the INEEL and adjacent properties, provides most of the water for the area surrounding the INEEL. Uses of the water from the aquifer include agriculture, food processing, aquaculture, and domestic, rural, public, and livestock water supplies. In total nearly 4.7 trillion gal (1.8E+07 m^3) of water are drawn from the aquifer annually with the majority going towards agriculture (DOE-ID 1998). In addition to providing water for INEEL site operations, the aquifer supplies water for other industries. Water discharged from springs in the Twin Falls–Hagerman area is used to raise fish commercially. The spring water flow of 1,660 ft^3/s (47 m^3/s) constitutes 76% of the water used for the commercial production of fish in Idaho. Most of these fish farms discharge water directly into the Snake River. The discharges from Hagerman Springs also significantly contribute to the flow of the Snake River downstream of Twin Falls, Idaho.

Table B-8. Estimated volume of water recharging the perched water bodies at INTEC.

	Northern INTEC		Entire Facility	
Source	Volume (gal/yr)	Percent	Volume (gal/yr)	Percent
Service wastewater	None	0	690,000,000	95.8
Sewage treatment ponds	15,000,000	58	15,000,000	2.1
Precipitation infiltration	3,800,000	15	8,000,000	1.1
Water system leaks	3,980,000	16	3,980,000	0.6
Landscape irrigation	1,568,000	6	1,568,000	0.2
Steam condensate	1,300,000	5	1,700,000	0.2
CPP-603 Basins	None	0.0	49,275	0.1
Total	25,648,000	100	720,297,275	100

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Groundwater in the aquifer generally flows from the northeastern recharge areas to the southwestern discharge areas. Nearly 6.5E+6 acre · ft (8.0E+9 m^3) of water is discharged by the aquifer annually. Most of the discharge occurs as spring flow between Hagerman and Twin Falls. About 2.1E+6 acre · ft (2.6E+9 m^3) of irrigation water are pumped from the SRPA in a typical year. About one-half of this water reenters the ground as return flow to the aquifer (DOE-ID 1999a).

The altitude of the regional groundwater surface underlying the INEEL ranges from about 4,600 ft (1,400 m) in the north to about 4,400 ft (1,300 m) near the southwest boundary of the INEEL. The average hydraulic gradient slopes to the south and southwest on the INEEL at about 10 ft/mi (1.9 m/km). Within the INEEL boundaries, the depth to the regional groundwater table ranges from 200 ft (61 m) BGL in the northeast to 900 ft (274.3 m) BGL in the west-southwest (DOE-ID 1999a).

The SRPA is the only source of water used at the INEEL. The combined groundwater withdrawal averages approximately 7.0E+6 gal/d (9.7E+6 m^3/yr) or 8,000 acres · ft/yr. Table B-9 lists the INEEL production wells, the depth of the well, the depth to water at the well, and the annual volume of water withdrawn from each well. All wells withdraw water from the main body of the SRPA. The water withdrawn from each well is used for potable water on the site, for ground maintenance, and necessary facility operations (DOE-ID 1999a). The underflow (i.e., that amount of water passing directly under the INEEL boundaries) is approximately 4.7E+11 gal/yr (1.8E+9 m^3/yr); the consumption is less than 1.0% of the INEEL underflow and less than 0.1% of the total annual aquifer discharge (DOE-ID 1999a).

Irrigated agriculture provides a significant portion of the economic base for the people of southern Idaho, and the SRPA plays a major role in meeting irrigation requirements. The aquifer provides groundwater for irrigation of over one-third of the 3 M irrigated acres (1.2 M ha) of the Snake River Plain. It is estimated that over 127,000 people depend on the aquifer for domestic and municipal water needs. Total domestic water consumption is approximately 46,000 acre · ft/yr (57 · m^3/yr) and groundwater discharge from well pumpage equals approximately 1.92 M acre · ft (2.37B · m^3) (EPA 1990).

B-6. GEOCHEMISTRY

Specific aspects of the geochemistry of the soil, concrete, grout, and basalt are presented in this section. The movement of contamination from the closed TFF is highly dependent on the sorptive properties of the contaminants in specific types of media (i.e., soil, concrete, grout) and specifically on the distribution coefficient (K_d) selected. The selection of soil K_d values is based on soil types similar to soils at the INEEL, and K_d values for other media are based on references and previous studies.

B-6.1 Sorption

The subsurface comprises surficial sediments, sedimentary interbeds, and basalt. There is limited site-specific adsorption information for contaminants in the subsurface environment at the INEEL (Del Debbio and Thomas 1989; Schmalz 1972). Distribution coefficients are available for cobalt, chromium, strontium, cesium, cadmium, mercury, and selenium for alluvium and cadmium, mercury, selenium, and strontium for interbed sediments and basalt. Limited availability of site-specific adsorption information for other radionuclides for sediments and basalts at the INEEL has resulted in the use of adsorption parameters measured for sediments and basalts from other sites (Maheras et al. 1994). Table B-10 summarizes the measured sorption coefficients values for the INEEL.

Several investigators have published compendia of soil and sediment distribution coefficient data (Baes and Sharp 1983; Coughtrey et al. 1985; Sheppard and Thibault 1990). The most thorough of these compendia is Sheppard and Thibault (1990), which contains a breakout of the distribution coefficients by major soil types (i.e., sand, loam, clay, and organic). Past

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Table B-9. INEEL production wells and annual volume pumped.

Well Name	Depth of well (ft BGL)[a]	Depth to Water (ft BGL)	Annual Volume (gal)
ANP-01	360	208	2.561E+06
ANP-02	340	211	1.433E+06
ANP-08	309	218	3.908E+05
Badging Facility well	644	489	5.760E+04
CFA-1	639	468	1.473E+07
CFA-2	681	471	1.448E+05
CPP-01	586	460	1.834E+08[b]
CPP-02	605	460	1.834E+08[b]
CPP-04	700	462	1.834E+08[b]
CPP-05	695	447	1.834E+08[b]
EBR-1	1075	596	4.491E+04
EBR II-1	745	632	2.767E+06[c]
EBR II-2	753	630	2.767E+06[c]
FET-1	330	199	1.427E+06
FET-2	455	200	5.067E+05
Fire Station well	516	420	1.057E+04
NRF-1	535	363	2.594E+06
NRF-2	529	362	9.368E+06
NRF-3	546	363	9.802E+04
NRF-4	597	363	1.649E+07
Rifle Range well	620	508	9.115E+04
RWMC Production	685	568	4.824E+05
SPERT-1	653	456	3.871E+05
SPERT-2	1217	463	3.450E+05
TRA-01	600	453	3.595E+07
TRA-03	602	456	2.074E+06
TRA-04	965	463	9.006E+07

a. ft BGL = feet below ground level

b. Annual volume data is the total for wells CPP-1, CPP-2, CPP-4, and CPP-5.

c. Annual volume data is the total for both wells EBR II-1 and EBR II-2.

All wells are withdrawing water from the main body of the Snake River Plain Aquifer and are used as drinking water wells with the exception of wells ANP-08 (fire station well) and NRF-4.

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Table B-10. Summary of sorption coefficients measured at the INEEL.

Element	K_d Values (mL/g)			Reference
	Alluvium	Interbed Sediment	Basalt	
Cd	4891–2864	10,115–8622	2319–785	Del Debbio and Thomas (1989)
Co	56	not measured	not measured	Schmalz (1972)
Cr	1.2	not measured	not measured	Schmalz (1972)
Cs	950	not measured	not measured	Schmalz (1972)
Hg	1921–236	673–72	87–9.2	Del Debbio and Thomas (1989)
Se	63–5.8	17–4.9	3.4–0.29	Del Debbio and Thomas (1989)
Sr	35–52	110–186	1.1–2.7	Del Debbio and Thomas (1989)
	24	not measured	not measured	Schmalz (1972)

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compendia grouped all soil types together. A major source of basalt adsorption information is available from investigations conducted during the Basalt Waste Isolation Project at Hanford, Washington, documented in the Nuclear Energy Agencies sorption database (Ticknor and Ruegger 1989).

B-6.2 Distribution Coefficients

Distribution coefficient values for radionuclides with no site-specific K_d values were taken from the Sheppard and Thibault (1990) analysis, which allowed a more realistic selection of K_d based on soil type similar to that at the INEEL. The surficial and interbed sediments at the INEEL are classified as a sandy loam and silty loam, respectively (Del Debbio and Thomas 1989). The sand category was selected to represent both the surficial and interbed sediments to conservatively estimate adsorption for the TFF as was done for the RWMC (Maheras et al. 1994; 1997). In addition, the sand category was also applied to the sand pads located beneath the tanks.

Distribution coefficient data for basalts are not as readily available as data for soils and sediments. The main source of K_d values is basalts from studies at Hanford. The appropriateness of using these K_d values at the INEEL is difficult to assess. The mineralogic differences have not been addressed, and the secondary minerals (e.g., clays and iron oxides), which form in the fractures and may have a major impact on the adsorption of many radionuclides, have not been quantified. Also, it is unclear if equilibrium is maintained during flow through the unsaturated zone. If local equilibrium is not valid, then the K_d values will overestimate the retardation of contaminants.

The modeling study conducted for the WAG 3 RI/FS incorporates sediment distribution coefficients for the alluvium and the interbed sediments, a zero distribution coefficient for the vadose zone basalts, and 1/25th of the sediment distribution coefficient for the aquifer basalts. The vadose zone basalts were assumed to have a zero distribution coefficient in the RI/FS based on the assumption that the water was expected to move more quickly through vertical fractures in the vadose zone, allowing very little time for the contaminant to sorb to the basalt. In the aquifer, the RI/FS modeling assumed that the water moves more slowly through the basalt fractures and matrix and there was sufficient time for the contaminants to sorb in the basalt. The RI/FS modeling also based the aquifer basalt distribution coefficients on an evaluation of the ratio of the distribution coefficient on sediments to that for basalt from the Del Debbio and Thomas report

(1989), where they found the ratio to be 1 to 25. Del Debbio and Thomas, however, provided conflicting information on the differences in sediment and basalt distribution coefficients. This report provides for higher distribution coefficients in the basalt based on breakthrough curve studies in comparison to the batch distribution coefficient study. Therefore, the appropriateness of the assignment of vadose and aquifer basalt distribution coefficient values is difficult to assess.

The distribution coefficients for basalts were treated as uncertain. Thus, three different applications of the basalt distribution coefficients were applied in the modeling. These applications were: (a) the distribution coefficients for sand from Sheppard and Thibault (1990) were used for the basalt. A comparison between the distribution coefficients selected for basalts in Maheras et al. (1994) and other INEEL groundwater studies (Rodriguez et al. 1997) indicate that the use of the sand distribution coefficients for the basalts are within the range of values reported in the literature for basalts; (b) application of a zero basalt distribution coefficient in the vadose zone and 1/25th of the sediment distribution coefficient to the aquifer basalts; and (c) application of 1/25th of the sediment distribution coefficient to all basalts.

Geochemical information and distribution coefficients for the grout and concrete for the TFF PA were taken from the work of Allard et al. (1985) and Bradbury and Sarott (1995). In an attempt to be consistent with other modeling analyses being conducted on the TFF (i.e., the HLW EIS), the interpretation of the distribution coefficients for grout and concrete were taken from Kimmel (2000). Kimmel (2000) provides an interpretation of the distribution coefficients provided by Bradbury and Sarott (1995) for application to the TFF. The interpretation applies non-reducing (oxidizing) concrete distribution coefficients to the concrete vaults; reducing concrete distribution coefficients to the grouted liquid wastes; and the assumption that the grouted heels are macro-encapsulated such that 50% of the heel is assumed to have a distribution coefficient equivalent to sand, and the remaining heel has the distribution coefficient properties of reducing grout. The radionuclide distribution coefficients selected for use in the TFF for the radionuclides of importance to the groundwater pathway are provided in Table B-11. It should be noted that the assumption of the oxidizing distribution coefficients for the concrete vault only alters the values for ^{99}Tc and the uranium isotopes, 1.0E–3 and 2.0 m^3/kg, respectively.

B-6.3 Solubility

Solubility limits for selected nuclides important to the groundwater pathway are provided in Table B-12 and were taken from Allard et al. (1985). Solubility limits were not applied to the contaminants in the grout for the TFF. Evaluation of the maximum solubility limits from Allard et al. (1985) and a comparison to the pore-water concentrations in the tank grout system indicated little difference between the solubility limits and pore-water concentrations (i.e., a factor of 10 or less); therefore, solubility limits were not applied.

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Table B-11. Distribution coefficients used in the TFF PA groundwater assessment.

	Distribution Coefficients - K_d [a]				
Element	Sand Pad (m^3 kg^{-1})	Alluvium (m^3 kg^{-1})	Grout (liquid wastes) (m^3 kg^{-1})	Grout (heel wastes) (m^3 kg^{-1})	Interbeds (m^3 kg^{-1})
Ac	4.50E–01	4.50E–01	5.00E+00	2.70E+00	4.50E–01
Am	1.90E+00	1.90E+00	5.00E+00	3.45E+00	1.90E+00
Cd	8.00E–02	8.00E–02	1.00E–01	9.00E–02	8.00E–02
Cm	4.00E+00	4.00E+00	5.00E+00	4.50E+00	4.00E+00
Cs	2.80E–01	2.80E–01	2.00E–02	1.50E–01	2.80E–01
H	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I	1.00E–03	1.00E–03	2.00E–03	1.50E–03	1.00E–03
Nb	1.60E–01	1.60E–01	5.00E–01	3.30E–01	1.60E–01
Ni	4.00E–01	4.00E–01	1.00E–01	2.50E–01	4.00E–01
Np	5.00E–03	5.00E–03	5.00E+00	2.50E+00	5.00E–03
Pa	5.50E–01	5.50E–01	5.00E+00	2.80E+00	5.50E–01
Pu	5.50E–01	5.50E–01	5.00E+00	2.80E+00	5.50E–01
Ra	5.00E–01	5.00E–01	5.00E–02	2.75E–01	5.00E–01
Se	1.50E–01	1.50E–01	1.00E–04	7.50E–02	1.50E–01
Sm	2.45E–01	2.45E–01	5.00E+00	2.60E+00	2.45E–01
Sn	1.30E–01	1.30E–01	1.00E+00	5.65E–01	1.30E–01
Sr	1.50E–02	1.50E–02	1.00E–03	8.00E–03	1.50E–02
Tc	1.00E–04	1.00E–04	1.00E+00	5.00E–01	1.00E–04
Th	3.20E+00	3.20E+00	5.00E+00	4.00E+00	3.20E+00
U	3.50E–02	3.50E–02	2.00E+00	1.00E+00	3.50E–02
Zr	6.00E–01	6.00E–01	5.00E+00	2.80E+00	6.00E–01

a. Basalt distribution coefficients were varied from equal to sand pad K_d; zero K_d in vadose zone and 1/25th the sand K_d value in the aquifer; and 1/25th the sand K_d value for all basalts.

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Table B-12. Solubility limits for the TFF grout.

Nuclide	Half-Life (yr)	Specific Activity Ci/g	Solubility Limit		
			Moles/L	Atoms/L	Ci/L
^{241}Am	4.32E+02	3.44E+00	3.70E–06	2.23E+18	3.06E–03
^{243}Am	7.38E+03	2.00E–01	3.70E–06	2.23E+18	1.79E–04
^{237}Np	2.14E+06	7.05E–04	1.00E–10	6.02E+13	1.67E–11
^{239}Pu	2.41E+04	6.22E–02	3.20E–11	1.93E+13	4.74E–10
^{238}Pu	8.78E+01	1.71E+01	3.20E–11	1.93E+13	1.30E–07
^{240}Pu	6.54E+03	2.28E–01	3.20E–11	1.93E+13	1.75E–09
^{241}Pu	1.44E+01	1.03E+02	3.20E–11	1.93E+13	7.93E–07
^{242}Pu	3.76E+05	3.93E–03	3.20E–11	1.93E+13	3.04E–11
^{230}Th	7.70E+04	2.02E–02	2.50E–10	1.51E+14	1.16E–09
^{234}U	2.45E+05	6.24E–03	2.50E–11	1.51E+13	3.64E–11
^{235}U	7.04E+08	2.16E–06	2.50E–11	1.51E+13	1.27E–14
^{236}U	3.42E+06	4.43E–04	2.50E–11	1.51E+13	2.61E–12
^{238}U	4.47E+09	3.36E–07	2.50E–11	1.51E+13	2.00E–15

Source: Allard et al. 1985.

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Appendix C

Idaho High Level Waste and Facility Disposition Final Environmental Impact Statement Responses to Public Comment (Tank Farm Specific Comments)

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Appendix C

Idaho High Level Waste and Facility Disposition Final Environmental Impact Statement Responses to Public Comment (Tank Farm Specific Comments)

The appendix provides a listing of the TFF specific public comments and responses resulting from the Idaho High Level Waste and Facility Disposition Final Environmental Impact Statement. The entire listing of comments and responses can be viewed in the EIS.

III.A Storage: Liquid Sodium-bearing Waste

III.A (1)

Comment - Commentors express concerns and opinions about the potential impacts of continued storage of SBW in the INTEC tank farm including:

- The possibility or existence of tank leakage or failures and the resulting impacts on the human health environment, from the Snake River Plain Aquifer, to the Snake and Columbia rivers, and eventually all of Idaho.
- Nuclear waste is already being transported to Hanford via contamination of the river system.
- Liquid wastes have been in storage for more than 50 years, 20 years beyond the tank design life.
- Despite DOE claims that the tanks have not leaked, they could in the 15 to 20 years it would take to implement a treatment alternative.
- The tanks and their concrete vaults do not meet seismic standards and could fail under a relatively minor seismic-induced stress.
- Leaks in the tanks or pipes should be repaired or new tanks should be built.
- Recommend quickly selecting and implementing an option to solidify liquid SBW due to the increased risks it poses in liquid form.
- Recommend quickly selecting and implementing an option to solidify liquid SBW due to the increased risks it poses in liquid form.

A commentor recommends that DOE postpone any further treatment of SBW beyond solidification until the ultimate disposal location has been identified.

Response - DOE recognizes there are risks associated with liquid waste storage, and, over the years, converted thousands of gallons of mixed HLW (completed February 1998) and some mixed transuranic waste/SBW from the INTEC tank farm into a more stable solid granular form called "calcine." This calcine is stored in bin sets estimated to provide safe containment for 500 years, pending final treatment and disposal decisions. Calcine processing at INTEC was suspended on May 31, 2000, in accordance with the Notice of Noncompliance Consent Order, leaving approximately one million gallons of mixed transuranic waste/SBW in the tanks. In the Record of Decision for this EIS, DOE will decide how to treat the liquids to expeditiously complete their removal from the 300,000-gallon tanks in the Tank Farm.

No liquid waste is known to have leaked from the 300,000-gallon underground storage tanks at the INTEC facility. However, despite the integrity of the tanks themselves, piping systems that connect the tanks and associated facility

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equipment, such as valves, have leaked. These problems have been corrected as they have been identified and the inter-tank transfer piping is now monitored by leak detection equipment. Presently, no lines are leaking. Primary contaminants of concern from past pipe system leakage include iodine-129, strontium-90, and tritium. Decisions related to remediation of Tank Farm soils will involve the EPA and the State of Idaho under the CERCLA process and will be part of the Record of Decision for the Operable Unit 3- 14 portion of Waste Area Group 3 at INTEC

See also responses to comment summaries in VII.C.

Recognizing the risks that tank leakage could present to the environment, DOE maintains a leak detection system at the INTEC tank farm, and the ability to transfer waste from any leaking tank to unused, reserve tanks. Although such a transfer has never been necessary, DOE maintains this mitigative capability. DOE also maintains a Tank Integrity Program that requires periodic corrosion testing and inspection of the tanks. Based on the corrosion and inspection data to date, the eleven 300,000-gallon storage tanks in the Tank Farm containing the remaining mixed transuranic waste/SBW have sufficient useable remaining service life to allow DOE to safely implement any of the waste processing alternatives. To date, no observable or measurable environmental impacts to the Snake River or Columbia River have resulted from INEEL activities. Since unevaporated surface water eventually migrates to the aquifer, the quality of water resources is verified by groundwater monitoring programs conducted by independent agencies such as U.S. Geological Survey and the State of Idaho INEEL Oversight Program. With improved management practices and remediation efforts planned or underway at INEEL, water quality in the Snake River Plain Aquifer is expected to improve. Therefore, no adverse environmental impacts to the Snake or Columbia Rivers resulting from past, present, or future INEEL operations are likely to occur.

Regarding structural integrity, it is true that the five pillar and panel tanks are located within concrete vaults that do not meet current seismic and structural standards, and that failure of these vaults could occur during a seismic event. DOE is evaporating the liquid in the remaining five tanks to reduce the volume and will transfer the liquid out of the pillar and panel tanks to one or more of the five remaining tanks (eleventh tank is a spare) to meet the June 2003 deadline established in the Notice of Noncompliance Consent Order signed by DOE, EPA, and the State of Idaho. See Section 5.2.14 of the EIS and Section 6.2.5 of the EIS Summary for potential environmental impacts of tank failure during a seismic event.

In 2005 or earlier, DOE intends to redirect all newly generated liquid waste to tanks that meet state and federal Resource Conservation and Recovery Act (RCRA) regulations, and no new liquid waste would be added to the tanks in the Tank Farm. DOE is also committed to cease use of the remaining RCRA non-compliant underground tanks by December 31, 2012 by either treating the liquid waste separately to render it to a solid form or transferring the waste to RCRA compliant tanks.

Draft Federal

III.A (2)

Comment - A commentor cites the Draft EIS Summary, Section 7.4, discussion of cumulative impacts to water, and asks if the term “design life” in reference to the underground HLW storage tanks is 500 years or estimated to be well in excess of 500 years.

Response - The storage tanks did not have an initial engineering requirement for a 500-year design life. However, recent in-tank inspections and measurement of corrosion test plates retrieved from the tanks show very little corrosion. The low corrosion rate is partially due to the acidic nature of the waste in the tanks and their stainless steel construction. The INEEL has a continuing tank inspection program. Data are obtained from the inspections and evaluations are performed to determine if the tanks’ design service life estimates need to be revised. Based on these evaluations, DOE estimates the tanks to have “service lives” well in excess of 500 years.

III.F.4 (2)

Comment - A commentor states that the EIS should identify potential offsite low-level waste

disposal facilities that would be available as well as the difficulties in using these potential disposal facilities. The Commentor also asks for contingency plans for low-level waste disposal. A commentor states that the Draft EIS does not adequately describe the storage plans (onsite and offsite) for various subclassifications of lowlevel waste.

Another commentor (EPA Region X) rates the Draft EIS as EC-2 (Environmental Concerns—Insufficient Information), citing uncertainties (due to a lack of analysis and documentation in the EIS) that facilities exist for handling and storing low-level waste.

Response - Section 5.2.13 of this EIS analyzes environmental impacts to facilities that would receive low-level waste from the treatment alternatives. This section states that annual production of low-level waste at the INEEL is currently about 2,900 cubic meters and although the peak annual quantity generated under the proposed action could be as high as 1,400 cubic meters, the highest annual average would be about 400 cubic meters. These quantities of low-level waste should not overload the INEEL's capacity and capability to accumulate, manage, and transport this type of waste.

In addition, this EIS analyzes three disposal options for low-level waste generated at the INEEL: (1) construction of a near-surface disposal facility, (2) use of existing INTEC facilities such as the Tank Farm and bin sets, and (3) transportation to an offsite disposal location. Offsite disposal facilities could accommodate the projected volumes of low-level waste that would be generated under the alternatives analyzed in this EIS. Those disposal facilities included in this EIS for analysis purposes are Envirocare of Utah for Class A-type low-level waste grout, and the Chem-Nuclear Systems disposal site in Barnwell, South Carolina for the Class C-type low-level waste grout. On February 25, 2000, DOE issued a Record of Decision for low-level waste and mixed lowlevel waste based on the Final Waste Management Programmatic EIS. In this Record of Decision, DOE decided to perform minimum low-level waste treatment at all sites and continue, to the extent practicable, onsite disposal of low-level waste at the INEEL and other DOE sites. In addition, this Record of Decision states that the Hanford Site in the State of Washington and the Nevada Test Site will be available to all DOE sites for disposal of low-level and mixed low-level waste.

IV FACILITY DISPOSITION IV.A Clean Closure

IV.A (1)

Comment - A commentor expresses doubt that the Clean Closure Alternative is worth the increased site worker mortality rate. Another commentor is of the opinion that 2,400 recordable injuries and 290 lost workdays (on page S- 55, left column of the Draft EIS) associated with clean closure of the INTEC Tank Farm seems excessively high and asks how these figures were derived.

Response - DOE shares the commentor's concern about the increased site-worker mortality rate under clean closure of the Tank Farm. DOE based the worker injury projection on a five-year average of lost workdays and total recordable illness/injury rates from INEEL construction workforce data from 1992 to 1997.

In the case of clean closure of the INTEC Tank Farm, DOE assumed that 280 workers, each working 2,000 hours per year, would be required for 27 years to clean close the Tank Farm. DOE calculated that for 280 workers, with a lost workday rate of 31.6 percent and a total recordable cases rate of 3.8 percent, there would be 2,388 total lost workdays and 287 total injuries/illnesses. DOE has updated the worker injury rates used in the Final EIS. Based on the updated information, DOE calculated that for 280 workers, with a lost workday rate of 28.4 percent and a total recordable cases rate of 3.7 percent, there would be 2,100 total lost workdays and 280 total injuries/illnesses. See Section 5.3.8 of this EIS.

IV.A (2)

Comment - A commentor supports the Clean Closure Alternative and states that contaminated

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underground structures such as tanks, vaults, and piping must be removed. Other commentors support the Clean Closure Alternative stating that DOE should remove wastes and keep background radiation at levels acceptable for general land use.

Response - Clean closure could make HLW facilities at INTEC available for general land use; however, there may be technological, economic, and worker health risks involved that would make it impractical to remove all residual material or decontaminate and remove all equipment from the INTEC facilities. RCRA hazardous waste regulation 40 CFR 264.197 states that if all contaminated system components, structures, and equipment cannot be adequately decontaminated, then the facilities must be closed in accordance with the closure and postclosure requirements that apply to landfills. These requirements would use performance based standards. As indicated in Section 3.4 of this EIS, which describes the preferred facility disposition alternative, performance-based standards would be applied to existing facilities based on risk calculations. New facilities, built at INTEC, would be designed consistent with clean-closure methods as required by current DOE orders. For all RCRA closures, detailed closure plans would first have to be developed by DOE and approved by the State of Idaho in accordance with hazardous waste management standards.

IV.C Closure to Landfill Standards

IV.C (1)

Comment - Commentors express varying preferences about selection of the tank closure alternatives including:

- The alternative for facility disposition should be closure to landfill standards because INEEL will continue to operate for many years.

- The complexity of disposing of contaminated 300,000-gallon waste tanks means that the "simple" solution of capping the tanks and "walking away" is unacceptable.

- Tank heels should be removed using demonstrated technologies, and then the tanks should be filled with grout.

A commentor states that closure of the tanks and soils as a landfill assumes that a cap would be placed over the waste to serve as a barrier against future leachate generation, which assumes that the associated CERCLA soils would also be capped. The Commentor also says that the Summary does not make clear what steps would be undertaken to meet the landfill closure goals.

A commentor expresses the opinion that unavoidable contaminated residues should be stored in well-defined, isolated, impervious spots.

Response - Tank closure to landfill standards would be performance-based, taking into consideration any contaminant levels that may exist and determine what if any amount of contaminant, including tank residuals, could be left without exceeding regulatory standards. Under the Preferred Facility Disposition Alternative, closure decisions would be made in the context of the impact of other facility closures in the area and CERCLA remediation efforts associated with the Tank Farm. Thus, the total residual burden to the environment from all remediation and closure activities in any area would be limited to a target value. Contaminants that exceed the limit would need to be reduced accordingly. Thus, although some contaminants could be left on site, including tank residuals, proper closure techniques to control or prevent dispersion to the environment would be implemented as required by closure permits.

As noted by the commentor, many release sites are being managed by CERCLA and the facilities being dispositioned under this EIS are colocated. Thus, it is important to coordinate facilities disposition with the decisions being made for release sites managed under CERCLA. These decisions on the final end-state for INTEC would consider the cumulative impacts of soils and groundwater contamination from release sites as well as facilities disposition activities. In this case, using an engineered cap over this area may be the final decision.

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DOE is committed to long-term stewardship of sites and facilities where closure decisions involve leaving contaminants in place. In such instances, DOE would institute protective measures including institutional controls that provide long-term barriers to inadvertent intrusion and monitoring efforts that determine the effectiveness of contaminant controls. See Section 6.3 of the Summary as well as Section 5.3 of this EIS for Closure to Landfill Standards information.

IV.C (2)

Comment - A commentor states that the Idaho Chemical Processing Plant (ICPP, now INTEC) would not qualify as a Subtitle-D dump because it lies in a flood plain.

Response - Based on the U.S. Geological Survey preliminary 100-year flood plain map, parts of INTEC are within the flood plain. However, the flood plain analysis conducted by the Bureau of Reclamation indicates that none of INTEC is within the 100-year flood plain. This information is presented in Section 4.8.1.3 of this EIS. DOE is currently conducting additional flood plain analysis to resolve the differences in the flood plain boundaries calculated by the U.S. Geological Survey and Bureau of Reclamation methods. Under RCRA regulations, closure of the INTEC Tank Farm and surrounding facilities could occur even within a flood plain because it would not be considered a new landfill facility. The cap for final closure of the INTEC Tank Farm would be designed to prevent significant erosion of the cap during a flooding event, which is one of the major concerns of closing landfills within a flood plain. For these reasons, DOE believes the issue of the flood plain can be adequately resolved during closure. See also Response to Comment summary VIII.C (5).

IV.C (3)

Comment - A commentor states that void spaces in empty tanks and containers represent a concern for landfill subsidence and require stabilization. The commentor proposes filling the voids with soil rather than Class A grout.

Response - The need to stabilize void spaces in tanks and containers to avoid subsidence is accounted for in all facility disposition alternatives involving the in-place disposal of facility structures and equipment. However, the use of soils rather than a grout mixture would not be practical due the technical difficulties that would be encountered trying to transport a soil mixture into the tanks and containers as well as into voids within and around equipment and structures left in place. An additional concern is the inability to achieve a compaction density of the soil equivalent to the compression strength achieved by a solidified grout.

IV.D Performance Based Closure with Low-level Waste Class A or Class C Grout

IV.D (1)

Comment - The commentor (EPA Region X) rates the Draft EIS as EC-2 (Environmental Concerns -- Insufficient Information), citing uncertainties (due to a lack of analysis and documentation in the EIS) that: Grout containing the low-level waste would prevent contamination of the aquifer for 500 years.

Response - Appendix C.9 of this EIS contains the reasoning for assuming that grouted low-level waste would remain intact for 500 years, after which it is assumed to fail. In stating this, DOE cites the Nuclear Regulatory Commission Branch Technical Position on Performance Assessment for Low-level Disposal Facilities (1994), which does not endorse the integrity of any manmade structure after 500 years. However, as evidenced by some studies, under certain conditions cementitious materials (such as grout or concrete) can be expected to last for extended periods of time, approaching 1000 years or more (Poe, W. L., Jr., "Long-term Degradation of Concrete Facilities Presently Used for Storage of Spent Nuclear Fuel and High-Level Waste," Rev. 1, Report Prepared for Use in Preparation of the Yucca Mountain EIS, Tetra Tech NUS, Aiken, South Carolina, October 1998). To address the commentors concern the analysis in Appendix C.9 was expanded to include a modeling scenario where low-level waste grout fails in 100 years. The potential environmental impacts to the aquifer are described in Appendix C.9 of this EIS.

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V WASTE DEFINITIONS, CHARACTERISTICS, AND QUANTITIES

V (1)

Comment - A commentor cites the Draft EIS Summary, Section 7.4, discussion of cumulative impacts and waste and materials, and states that the INEEL waste inventory as presented does not include HLW.

Response - As stated in Section 6.4 of the Summary of this Final EIS, the waste inventory referred to by the commentor is that INEEL waste in addition to the inventory of mixed HLW calcine and mixed transuranic waste/SBW targeted for treatment as part of the actions evaluated in this EIS. DOE proposes to prepare the inventory of calcine and mixed transuranic waste/SBW so that it is ready for removal from the State of Idaho. The EIS considers the environmental impacts of waste generated during the treatment of calcine and mixed transuranic waste/SBW (referred to in the EIS as process wastes) or shipping the calcine directly to the repository. These process wastes must be treated, stored, and disposed of in addition to other INEEL legacy wastes and newly generated wastes and are evaluated as cumulative environmental impacts in the EIS.

V (2)

Comment - A commentor questions statements in the Draft EIS regarding waste streams that would result from implementation of waste treatment options:

- The Draft EIS Summary states that construction activities would generate little radioactive and hazardous waste, but the volume reported for Full Separations construction impacts (over 2,000 cubic meters) does seem significant.

- The Draft EIS Summary identifies radioactive waste as part of construction wastes. How is radioactive waste generated during the construction process?

Commentors request that DOE add a clear definition of newly generated liquid waste in one or more places in the EIS, including the glossary.

Response - It is DOE's policy to minimize the generation of waste. Therefore, it may be possible for DOE to reduce the generation of waste under the Full Separations Option to something less than 2000 cubic meters. However, for comparative purposes, conservative estimates of generated waste were used and these relative quantities were factored into the analysis of the alternatives presented in this EIS.

Sections 6.2.4 and 6.3.4 of the Summary and Section 5.2.13 of this EIS discuss waste produced under the waste processing and facility disposition alternatives. Table S-2, pages 3 and 4 of 12, (Final EIS Summary) summarizes these environmental impacts from waste and materials. Section 6.2.4 of the Summary shows that construction activities produce relatively little radioactive or hazardous wastes and that this EIS examines environmental impacts associated with generation of both radioactive and non-radioactive wastes resulting from construction and waste processing operations. Construction activities created radioactive waste because of new or modified facilities are tied into existing contaminated structures – for example, via piping and ventilation connections.

Newly generated liquid waste was defined in the text box of page xi of the draft EIS summary, and it characteristics were given in the text box on page 3-11 of the Draft EIS. However, it definition was inadvertently omitted from the glossary located in Appendix D of the Draft EIS and the acronym was omitted from the Document Wide Acronym and Abbreviation list. In response to this comment, the definition of the newly generated liquid waste was added to the revised glossary (Chapter 7 of the Final EIS), and the acronym was added to the revised acronym of this EIS.

V (12)

Comment - A commentor asserts that DOE is attempting to reclassify SBW, Tank Farm residuals, HLW in ancillary piping, waste residues in ventilation ducts, and waste leaked from piping as waste forms other than HLW to avoid

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regulatory or disposal requirements. The commentor also states that SBW is specifically either first cycle raffinate or has been diluted to avoid classification as HLW. The commentor says that DOE is attempting to reclassify Tank Farm heels and other HLW to other ancillary waste streams and fails to recognize that "incidental waste" still falls under the classification of HLW.

Commentors also state that DOE must describe the processes used for reclassification of HLW fractions resulting from separations to other waste forms such as transuranic waste, and must also describe associated uncertainties. A commentor asserts that DOE processes used to reclassify waste at the Savannah River and Idaho sites are against the law, are rightfully opposed by the states of Washington, Idaho, and Oregon, and violate the Settlement Agreement/Consent Order.

Response - In developing the waste processing alternatives analyzed in this EIS, DOE made certain assumptions about how the radioactive waste streams that would go into and come out of the selected treatment processes would be classified. DOE would classify all radioactive wastes in accordance with the processes described in DOE Order 435.1 and Manual 435.1-1 (Radioactive Waste Management Order and Manual). The term "waste incidental to reprocessing" is used when referring to a process for determining whether wastes that might be considered HLW due to their origin could be managed as low-level or transuranic waste. This process, which is included in DOE Order 435.1 and Manual 435.1-1, ensures that radioactive wastes are managed appropriately based on the risk they pose to the public and the environment. It is DOE's position that the waste incidental to reprocessing process, described in a Chapter 2 text box (page 2-9) and Section 6.3.2.2 of this EIS, is consistent with law and current policies of the Nuclear Regulatory Commission with respect to incidental wastes.

The State of Idaho does not oppose DOE's plan to classify SBW through the process delineated in DOE Order 435.1 and Manual 435.1-1, provided that all constituent parts of the waste are disposed out of the State of Idaho, in accordance with the terms of the Settlement Agreement/Consent Order, and managed in compliance with regulatory requirements. The State expects residual wastes to be managed and monitored in accordance with the applicable requirements of RCRA, the Idaho Hazardous Waste Management Act (HWMA), and the CERCLA Record of Decision for Waste Area Group 3 for the INEEL.

Waste incidental to reprocessing determinations are being developed for waste streams at INTEC, as described below. These waste streams include the existing mixed transuranic waste/SBW in the Tank Farm, the residual waste material remaining in the Tank Farm tanks after cleaning and closure, contaminated job wastes, and contaminated equipment (pumps, valves, etc.) used in HLW process systems.

Mixed transuranic waste/SBW - The existing inventory of mixed transuranic waste/SBW in the Tank Farm tanks at INTEC includes waste streams associated with spent fuel reprocessing. However, most of the liquid wastes sent to the Tank Farm during past reprocessing operations have been removed from the tanks and solidified by the calcination process. The bulk of the remaining inventory is comprised of waste solutions from plant decontamination activities and processes ancillary to reprocessing, although a small fraction of the Tank Farm Inventory is attributed directly to reprocessing extraction wastes. When compared to first cycle extraction wastes, the current inventory of mixed transuranic waste/SBW is generally much lower in radioactivity, and therefore poses significantly less risk. Of the approximately 44 million curies that resulted from spent nuclear fuel reprocessing at INTEC, about 43.5 million curies have been calcined or have decayed. Of this amount about 480,000 curies remains in the mixed transuranic waste/SBW. A waste incidental to reprocessing determination (by the evaluation method) draft has been prepared to evaluate whether the remaining mixed transuranic waste/SBW should be managed and disposed of as transuranic waste. The Nuclear Regulatory Commission is performing a technical review of the draft waste incidental to reprocessing determination prior to

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its finalization by DOE, which is anticipated in 2002.

Tank Farm Residuals - Closure of the HLW tanks is planned at INTEC. As treatment of the mixed transuranic waste/SBW is completed and the Tank Farm tanks are emptied, the tanks would be flushed to maximize waste removal. Flushing activities would remove waste to the maximum extent that is technically and economically feasible, and to a level that meets regulatory requirements for long term protection of the environment. However, some amount of residual waste will likely be unable to be retrieved from the tanks. A waste incidental to reprocessing determination (by the evaluation method) has been prepared for these Tank Farm residuals, which evaluates whether the waste remaining in the tanks after closure should be managed as low-level waste. The Nuclear Regulatory Commission will perform a technical review of the draft waste incidental to reprocessing determination prior to its finalization by DOE, which is anticipated in 2003.

There are two other waste streams eligible for waste incidental to reprocessing determinations. These determinations can be by either a citation of evaluation method as determined by applying DOE Order 435.1 and Manual 435.1-1 requirements to the waste. Waste incidental to reprocessing determinations are being developed to determine if contaminated job wastes and contaminated equipment and material meet the requirements to be managed and disposed of as low level or transuranic waste.

Contaminated Job Wastes - Wastes generated during HLW transfer, pretreatment, treatment, storage, and disposal maintenance, operating, sampling and analysis, closure, and decontamination activities and equivalent items are eligible for the waste incidental to reprocessing citation determination process. Contaminated job wastes contain small amounts of radioactivity on the materials in low concentrations or are limited to low levels on the components' surfaces. DOE Order 435.1 cites items eligible for the waste incidental to reprocessing citation determination process.

Contaminated Equipment and Materials - This waste incidental to reprocessing determination will cover contaminated equipment and materials removed from INTEC HLW facilities for disposal. The evaluation waste incidental to reprocessing determination will be prepared for the miscellaneous equipment and other related materials potentially contaminated by HLW reprocessing streams that have been or will be removed from service.

VII.B CERCLA

VII.B (1)

Comment - Several commentors state that DOE should coordinate treatment to address all forms of contamination including groundwater, soil, facilities, and HLW. One commentor states that the consequences of cleanup should be examined so that the problem of dealing with contaminated soils in the future is not compounded. Another commentor states that soil contamination from previous INTEC Tank Farm piping system releases is being evaluated by the CERCLA program, but that this issue is not being considered in the EIS.

Response - DOE is aware of the benefits of coordinating waste treatment activities and has addressed this issue in this EIS with respect to INTEC. As explained in Section 6.3.2 of this EIS, the waste treatment and facility disposition activities selected by DOE would be closely coordinated with ongoing CERCLA and other waste management and environmental restoration actions at INTEC. The releases from the INTEC Tank Farm piping system are being considered in this EIS from a cumulative environmental impacts standpoint. See Responses to Comment summaries IV.A (2), IV.C (2), IV.C (3).

VII.B (2)

Comment – A commentor states that remediation of the INTEC Tank Farm soils must be conducted in accordance with the Nuclear Regulatory Commission HLW disposal requirements as well as Applicable or Relevant and Appropriate Requirements under the CERCLA program.

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Response - DOE, not the Nuclear Regulatory Commission, is responsible for managing contaminated soils at INTEC. The soils will be managed in accordance with DOE orders and other applicable or relevant and appropriate requirements agreed to by EPA and the State of Idaho and specified in the CERCLA Record of Decision.

VII.B (3)

Comment - Several commentors recommend that the cleanup be conducted on a prioritized schedule and that the highest risk waste at the INEEL be dealt with first. One commentor adds that the liquid waste at INTEC should be a high priority.

Response - Remediation of contaminated sites at the INEEL is proceeding on a schedule under CERCLA. The radioactive liquid waste in the INTEC Tank Farm represents a higher near-term risk than the calcine in the bin sets under nonaccident conditions. Except for the No Action Alternative, all of the waste processing alternatives evaluated in this EIS would treat the liquid waste in the INTEC Tank Farm first. The State of Idaho believes the liquid mixed transuranic waste/SBW in the tanks could present the highest long-term risk and agrees it should be dealt with first. The National Academy of Sciences also recommends treating the liquid mixed transuranic waste/SBW first.

VII.C RCRA VII.C (1)

Comment - A commentor states that the DOE document, "Regulatory Analysis and Proposed Path Forward for INEEL High-Level Waste Program," is a shocking rerun of the terminated Hanford tank waste grouting program. The commentor also refers to DOE's actions at the Savannah River Site and the INEEL's intent to illegally delist HLW at the Tank Farm.

Response - The regulatory analysis document that the commentor refers to was developed to determine the appropriate list of hazardous waste codes for the INTEC Tank Farm waste. The analysis resulted in four listed waste codes comprising nine listed waste constituents. As a result of the document, the revised list of RCRA listed waste constituents has been identified and presented to the State of Idaho for review and concurrence. Once concurrence is reached, a plan for future management of this waste can be determined. With regard to delisting of waste codes, this EIS discusses in detail the EPA approved process DOE would follow if the INEEL mixed HLW is to be delisted before disposal. See Sections 6.3.2.1 and 6.3.2.3 of this EIS. Activities at the Savannah River Site and the Hanford grouting program are outside of the scope of this EIS.

VII.C (4)

Comment - A commentor states that the highlevel liquid waste in the Tank Farm is considered "mixed hazardous waste," yet DOE is not complying with legal requirements, nor is the state or the EPA adequately exercising their regulatory authority.

Response - As discussed in Chapter 1 of this EIS, DOE must decide how to treat the liquids so DOE can cease use of the tanks by December 2012 in accordance with the Notice of Noncompliance Consent Order. Ceasing use of the tanks, which do not have compliant secondary containment and, therefore, do not comply with hazardous waste regulation, is a priority for DOE and the State of Idaho. DOE could also meet its commitment to cease use of the underground tanks by employing compliant tanks to store any liquid remaining after 2012. The EPA and the State of Idaho have adequately exercised their regulatory authority.

VII.D Settlement Agreement Consent Order

VII.D (1)

Comment - Commentors caution against adherence to Settlement Agreement/Consent Order provisions at the expense of public health and the environment. Specifically, Commentors stress the need to establish a more realistic schedule that gives DOE time to plan and implement a HLW treatment program that protects Idaho and its environment.

Response - DOE's plan and schedule with the State of Idaho under the Settlement

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Agreement/Consent Order for waste treatment at INEEL is contemplated to be completed by a target date of December 31, 2035. DOE intends to aggressively pursue the means to implement the Settlement Agreement/Consent Order because it is in the best interest of public health and the environment. Protection of human health and the environment is the primary impetus behind the Settlement Agreement/Consent Order. By its implementation, radioactive liquid would be removed from tanks that do not meet regulations, thus reducing the risk of contamination to the Snake River Plain Aquifer. Further, DOE agrees to place the mixed transuranic waste/SBW and mixed HLW calcine in a form suitable for transport to a disposal or storage facility outside Idaho. DOE successfully calcined all of the liquid mixed HLW in the tanks and commenced calcination of the mixed transuranic waste/SBW, in accordance with the Settlement Agreement/Consent Order milestones, prior to placing the calciner in standby.

All treatment alternatives evaluated in this EIS would pose a small risk to public health and the environment during the years of operation, eliminate risks to the groundwater, put wastes into a solid form suitable for disposal, and meet the Settlement Agreement/Consent Order road-ready target date of December 31, 2035. Only the No Action and Continued Current Operations alternatives, which would leave waste in storage after 2035, could result in long-term risks to public health and the environment.

VII.D (2)

Comment - Commentors ask whether the state's concurrence on the Draft EIS is an indication of the state's willingness to change the Settlement Agreement/Consent Order. Further, if changes are not made to this agreement, how would DOE solve the HLW issues? A commentor states that, in any event, the public must be kept informed of DOE plans.

Response - One of the primary reasons the State of Idaho agreed to be a cooperating agency is Section E6 of the Settlement Agreement/Consent Order, which directs both DOE and the State to begin negotiation on a plan and schedule for the treatment of calcined waste by December 31, 1999. Both parties agree that this milestone was met by working together on this EIS, which evaluates alternative ways to prepare the calcine so that it will be suitable for disposal.

The State of Idaho was aware that DOE was also preparing the EIS to take a comprehensive look at the entire HLW program at INTEC and that this evaluation could form the basis for proposals to modify the Settlement Agreement/Consent Order, as provided by Section J4 of the agreement, which reads:

"In the event any required National Environmental Policy Act analysis results in the selection after October 16, 1995, of an action which conflicts with any action identified in this Agreement, DOE or the Navy may request a modification of this Agreement to conform the action in the Agreement to that selected action. Approval of such modification shall not be unreasonably withheld. If the State refuses to accept the requested modification, DOE or the Navy may seek relief from the Court. On motion of any party, the Court may extend the time for DOE or the Navy to perform until the Court has decided whether to grant relief. If the Court determines that the State has unreasonably withheld approval, the Agreement shall be conformed to the selected action. If the Court determines that the State has reasonably withheld approval, the time for DOE or the Navy to perform the action at issue shall be as set forth in this Agreement and subject to enforcement as set forth section in Section K.1."

The State of Idaho concurred on the EIS as a cooperating agency. Concurrence means that state representatives have participated in the development, review, and preparation of the document and found it to adequately analyze the environmental issues it addresses as required by Council on Environmental Quality guidance. However, the EIS itself does not make decisions, and the State's concurrence on the EIS does not predetermine its reaction to any agreement modifications DOE may propose. The State of Idaho is willing to consider proposed changes to the Settlement Agreement/Consent Order that would provide more environmental benefits within the same timeframe. The Planning Basis

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Option in the EIS describes how DOE proposes to manage its HLW issues without modifying the Settlement Agreement/Consent Order.

DOE will announce its plans for managing HLW at INTEC in a Record of Decision published in the Federal Register. If these plans are inconsistent with the Settlement Agreement/Consent Order, they may require negotiations with the State of Idaho. Notification of the availability of the decision will be sent to recipients of the Final EIS and to anyone who expresses an interest in receiving this information. The public is always encouraged to contact DOE or the State of Idaho regarding DOE's plans and status of implementation.

VII.D (3)

Comment - A commentor suggests that the EIS analyze all reasonable and technically viable alternatives, not just those considered politically feasible or those meeting Settlement Agreement/Consent Order milestones.

One commentor states the opinion that the term "road ready" defines a political goal that is driven by a political agenda. Another commentor asks if Idaho Department of Environmental Quality and EPA regulatory standards are based on scientific and health considerations or on political considerations. A commentor states that DOE's mission is to get reprocessing waste "road ready" and not "make work" for thousands of employees or justify dumb decisions made elsewhere with respect to implementing/siting repositories and categorizing radioactive wastes.

Response - DOE believes that this EIS presents the range of reasonable alternatives, the selection of which was not constrained by political considerations or limited by the requirements of the Settlement Agreement/Consent Order. Among the alternatives analyzed in this EIS, only the Planning Basis Option of the Separations Alternative reflects verbatim agreement commitments, as well as other legal requirements and associated DOE decisions. One of the primary purposes for preparing this EIS is to address alternative methods of treating the remaining liquid mixed transuranic waste/SBW in the underground tanks and preparing the mixed HLW calcine so that it will be suitable for disposal. It was recognized that alternative waste treatment methods may necessitate changes in the Settlement Agreement/Consent Order, and this EIS identifies in each case how compliance would be affected. Further, additional alternatives proposed through the public comment process were evaluated after release of the Draft EIS to determine if any provided an advantage over those already analyzed. In response to public comment, a new option was added to this EIS. This option under the Non-Separations Alternative is called Steam Reforming and includes direct disposal of the mixed HLW calcine in the geologic repository. DOE continues to stay informed about potential new waste management technologies and, when appropriate, conducts evaluations to determine if such technologies could optimize waste management operations.

The term "road ready" describes the condition in which HLW may be safely transported and accepted by a designated storage or disposal facility. It is a term that DOE and the State of Idaho use to describe the INEEL treated mixed HLW by the target date of December 2035. This date was agreed upon because this is when DOE believes it can reasonably accomplish the task. This date was negotiated by political entities. The overriding concern was human health and protection of the environment, not to make work for employees. In performing its activities, DOE complies with applicable regulatory standards established to protect human health and the environment. Some relevant agencies responsible for ensuring compliance include the EPA, the U.S. Department of Transportation, and the State of Idaho. Environmental regulatory standards are based on scientific and health considerations promulgated through processes which include public input. See response to comment summary VII.D (1).

VII.D (6)

Comment -Commentors state that DOE should select an alternative that meets the requirements of the Settlement Agreement/Consent Order and that DOE should:

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- Treat all liquid and calcined wastes and remove them (including tank heels) from the INEEL.

- Close the INTEC Tank Farm as they are emptied (focusing first on the pillar and panel tanks).

- Make treated waste ready for shipment out of Idaho by 2035.

- Retrieve, solidify, and store remaining liquid waste to reduce threats to the groundwater.

- Immobilize all wastes as soon as possible to reduce cost and make treatment easier.

- Adhere to the provisions of this agreement, including getting the waste out of Idaho.

- Maintain deadlines.

- Calcine all the liquid waste as promised; this technology is the only one that will enable DOE to meet its obligation of removing the SBW from the tanks by 2012.

- Combine liquid waste and HLW calcine in bin sets where it can be retrieved, treated, and made ready to leave Idaho by 2035.

- Get the waste out of Idaho somehow. commentors also say that any alternative that leaves this waste permanently in Idaho, such as grouting waste in storage tanks, would be inconsistent with the provisions of the Settlement Agreement/Consent Order.

Response - In accordance with the Settlement Agreement/Consent Order, DOE has already completed the following milestones relating to management of HLW:

- Complete calcination of liquid mixed HLW by June 30, 1998 (completed February 22, 1998).

- Begin calcination of liquid mixed transuranic waste/SBW by June 2001 (completed February 1998).

- Start negotiations with the State of Idaho regarding a plan and schedule for treating calcined waste by December 31, 1999 (actual, September 1999). The plan and schedule for treating INEEL HLW would be established by the Record of Decision for this EIS and would be the basis for consideration of associated Settlement Agreement/Consent Order matters.

DOE is committed to complying with the Settlement Agreement/Consent Order, and the State of Idaho agrees with Commentors that deadlines are important to ensuring continued progress in treating and removing waste from Idaho. As noted in this EIS, Section J4 of the Settlement Agreement/Consent Order provides a process whereby DOE can propose changes to the agreement based on a required National Environmental Policy Act analysis. See response to comment summary VII.D (2). Based on this EIS, DOE could request a modification to the Settlement Agreement/Consent Order, such as using a technology other than calcination to solidify mixed transuranic waste/SBW. While this EIS indicates that most alternatives with or without the calciner could fail to meet the December 2012 date for removal of the liquid mixed transuranic/SBW from the RCRA noncompliant tanks, there were many assumptions built into those schedules, which may or may not materialize. Nevertheless, any liquid remaining above heel level could be transferred to newly constructed or upgraded compliant tanks which would enable DOE to cease use of noncompliant underground tanks on schedule. Thus, based on this EIS, DOE could propose a modification to the Settlement Agreement/Consent Order that would be consistent with DOE's decision regarding treatment of mixed transuranic waste/SBW as documented in the Record of Decision resulting from this EIS. The State of Idaho will carefully evaluate any proposed modification to determine whether it is reasonable.

Combining mixed transuranic waste/SBW and mixed HLW calcine is an alternative evaluated in this EIS. However, it is not the only alternative that would enable DOE to treat the waste by the target date of December 2035 to have it ready to leave Idaho. With the exception of the No Action and Continued Current Operations alternatives, all

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the other waste processing alternatives would meet the 2035 target date, whether involving separations or non-separations.

The State of Idaho's position is that alternatives that involve disposal of grouted waste in below grade tanks in the Tank Farm at INTEC would be a violation of the Settlement Agreement/Consent Order. Any residual hazardous waste contamination associated with facilities would be addressed through state approved facility RCRA closure plans following public review.

VIII.C Water Resources

VIII.C (1)

Comment - Several commentors state that both the chemical and radiological toxicity of waste must be considered. Also, the commentors state that several comparisons should be made between the amount of liquid waste in the INTEC Tank Farm and the amount of water in the Snake River Plain Aquifer, including the amount of water necessary to dilute the waste to the drinking water standards. A commentor expresses concern that a leak in the waste tanks could jeopardize Idaho's primary water source.

Response - The EIS addresses the potential environmental impacts to the Snake River Plain Aquifer from the range of reasonable alternatives, as well as contaminants known to be present in the aquifer based on past practices at the INEEL and water sampling data. These potential environmental impacts and existing pollutants in the aquifer include both radioactive and nonradioactive contaminants. Extensive groundwater monitoring programs conducted by the U.S. Geological Survey, the State of Idaho, and DOE indicate that no contaminants attributable to INEEL activities currently exceed EPA drinking water standards at the site boundary.

The volume of water present in the Snake River Plain Aquifer would dilute the maximum potential burden from existing and potential contaminants to far below EPA drinking water standards. However, evaluating the quantity of contaminants in the waste and comparing that to the total volume of water in the aquifer greatly over-simplifies contaminant transport through the vadose zone and the aquifer.

For example, the total curies of iodine-129 in the Tank Farm under the No Action Alternative is 0.73 curies, and the total volume of the aquifer is estimated to be 2 billion acre-ft, or approximately 650 trillion gallons (2,500,000,000,000,000 liters). If the total curies of I-129 were mixed directly into the aquifer and spread evenly throughout the total volume of the water in the aquifer, the concentration would be approximately 0.0003 picocuries per liter, compared to the drinking water maximum contaminant level of 1 picocurie per liter. However, this illustrative scenario could not occur because there are interactions between the soil and waste in the vadose zone and the aquifer that retard the movement of the contaminants (both radionuclides and nonradionuclide contaminants), such as adsorption and impermeable rock that result in zones of perched water.

Additionally, waste would not be dispersed through the whole aquifer, but would be concentrated in plumes down-gradient from the source of contamination. Figures 4-13, -14 and -15 in Chapter 4 are examples of plumes from contaminant sources at INTEC. The groundwater velocity in the aquifer under INTEC has been estimated between 10 to 25 feet per day. In a river, velocity is usually measured in feet per second. This comparison between the velocity in a river and in an aquifer is indicative of the difference in dispersion between the two. Contaminants placed directly in a river would disperse relatively quickly downstream. In an aquifer, dispersion is a very slow process, slowed even more by adsorption of contaminants into the soil.

Because of these differences, modeling of the various processes affecting groundwater transport is performed rather than reporting the total amount of contaminants mixed throughout the whole aquifer. Appendix C.9 describes the modeling of both the radioactive and nonradioactive contaminants performed for this EIS. In addition, Section 5.2.14, Facility Accidents, modeled events and the associated

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potential environmental impacts to the aquifer. To minimize potential for a tank leak, DOE is committed to cease use of the eleven tanks in the Tank Farm by December 31, 2012.

VIII.C (2)

Comment - A commentor states that the information contained in Appendix C.8 should be expanded to include a discussion of the uses of the Columbia River along with the impacts of the alternatives on these uses of the river.

Response - Environmental impacts to the Columbia River from processing at Hanford are covered in more detail in the Tank Waste Remediation System EIS, DOE/EIS-0189, August 1996. For the Minimum INEEL Processing Alternative, DOE summarized the potential environmental impacts to the Hanford area from processing INEEL waste and the environmental impacts to the INEEL to provide a basis for comparison between alternatives. If the Minimum INEEL Processing Alternative or a hybrid Hanford option were selected for implementation in the Record of Decision, DOE would review the need for additional site-specific National Environmental Policy Act documentation, as necessary, including analysis of environmental impacts at the Hanford Site and the Columbia River. See response to comment summary VII.A (2).

VIII.C (3)

Comment - A commentor states that the groundwater modeling was overly simplified and failed to consider uncertainties and preferential pathways for migration. In addition, the commentor recommends that these uncertainties be discussed in the EIS.

Response - While the models used to predict waste migration through the vadose zone do not examine in detail the preferential pathways through the vadose zone and aquifer, DOE believes the models are sufficiently conservative to bound the environmental impacts. A sensitivity analysis including a discussion of the uncertainties has been incorporated into Appendix C.9.

VIII.C (4)

Comment - Commentors question the use of a 500-year design life for grout and state that the groundwater impacts should be evaluated for failure of the grout at shorter time frames. One Commentor expresses particular concern over I-129 leaching from the grout and impacting groundwater coincident with peak concentrations from the former INTEC injection well.

Response - As documented in Appendix C.9, DOE performed a quantitative sensitivity analysis of the effect of changes in assumed time of grout failure (as well as infiltration rate and distribution coefficient) on the resulting groundwater concentrations. DOE used the Tank Farm - Performance-Based Closure or Closure to Landfill Standards as the basis for this sensitivity analysis. The time of grout failure sensitivity analysis was performed for 100- and 1,000-year grout failure times in addition to the 500 years analyzed in this EIS.

The commentors concerns about I-129 leaching and cumulative environmental impacts to the aquifer are addressed in this EIS. If the grout fails at 100 years, the cumulative impact would include both the contaminants from the grout failure and the prior contamination from the injection well (reduced to a concentration below drinking water standards). Cumulative environmental impacts of grout failure combined with contamination remaining from the injection well are covered in Section 5.4 of this EIS.

VIII.C (5)

Comment - Commentors state that DOE should use the U.S. Geological Survey flood plain estimate because it is more conservative than the U.S. Bureau of Reclamation estimate. Commentors also express further concern with waste remaining within either the 100-year (U.S. Geological Survey) or 500-year (Bureau of Reclamation) flood plains and state that the structures should be designed to withstand either flood event.

Another commentor is concerned that contamination remaining in the INEEL soils may eventually be in the pathway of any flood or alteration of the flow pattern of the Big Lost

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River, whose meander patterns are susceptible to large variations due to the Arco Desert Plain's low gradient. A commentor states that DOE should not base programmatically critical decisions on the U.S. Geological Survey report because it is excessively conservative and/or incorrect.

Another commentor notes the following specific concerns:

1. The report does not accurately represent Big Lost River/Birch Creek 100-year flows because the combined probability of all the assumptions used to estimate the flow frequency results in a frequency that is much less than 1 in 100.

2. Procedures used to determine 100-year flow below the Mackay Dam are inappropriately applied in order to produce the largest possible flow.

3. Information about inflow into Mackay Reservoir is incomplete because it does not account for the fact that most surface water flows from snow melt, nor does it include data about the design discharge of the dam or historical releases relating to past floods cited.

4. Estimates of flood frequency may be inaccurate because they are based on old data, or data developed with older estimating techniques.

Response - Commentors concerns regarding data quality, assumptions, probabilities and flood frequency are being addressed as part of ongoing studies being conducted by the Bureau of Reclamation and the U.S. Geological Survey. It is expected these studies will be completed in 2002. Following review and evaluation by the INEEL Natural Phenomena Hazards Committee, the DOE Idaho Operations Office will issue a formal Floodplain Determination in accordance with 10 CFR 1022. The Floodplain Determination will be based on a map identifying the 100- and 500-year flood elevations.

As discussed in Section 4.8.1.3 of the EIS, estimates for the 100-year flood were most recently published by the U.S. Geological Survey (Berenbrock and Kjelstrom 1996) and by the Bureau of Reclamation (Ostenaa et al. 1999). These studies differ markedly in their estimation of the 100-year return period flood. The U.S. Geological Survey used conventional flood-frequency and regional regression analysis to determine a 100-year flow rate of 6,220 cubic feet per second (cfs) for the Big Lost River downstream of the INEEL Diversion Dam. For the purposes of this study, the INEEL Diversion Dam was assumed not to exist. The Bureau of Reclamation utilized a probabilistic approach based on paleoflood, soils, stream gauge, and geomorphic analyses. These analyses were conducted along two different two-mile study areas on the lower reaches of the Big Lost River on the INEEL to estimate a 100-year flow of 3,270 cfs. The Bureau of Reclamation approach meets requirements delineated in DOE standards for the determination of flood hazards.

Faced with this considerable difference in estimates of the 100-year flood, DOE established a Flood Subcommittee of the INEEL Natural Phenomena Hazards Committee. The subcommittee consists of DOE personnel as well as experts from the U.S. Geological Survey and management and operating contractors working at the INEEL. The subcommittee met several times in 2000, after the comment response period on the Draft EIS was concluded, to evaluate and critique the U.S. Geological Survey and Bureau of Reclamation reports as well as other applicable reports. The subcommittee also conducted a field trip to the lower reaches of the Big Lost River accompanied by U.S. Geological Survey and Bureau of Reclamation.

Based upon this review, the subcommittee recommended that additional field studies and analyses be performed by both the U.S. Geological Survey and Bureau of Reclamation to more fully address specific questions regarding assumptions and analyses used by each agency. The additional field work started in August 2000.

A U.S. Army Corps of Engineers analysis of existing data (Bhamidipaty 1997) and INEEL geotechnical analysis (INEEL/INT-98-0090) concluded that the INEEL Diversion Dam

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structures could withstand flood flows up to 6,000 cfs. Culverts running through the diversion structure could convey a maximum of 900 cfs downstream but their condition and capacity as a function of water elevation is unknown (Bhamidipaty 1997). This preliminary analysis indicates that the diversion dike would tend to reduce the impact of the 100-year flood on INEEL facilities. The flood-hazard mitigation potential of the INEEL Diversion Dam will be further evaluated as the flood hazard studies are completed.

In this EIS, DOE analyzed the environmental impacts that would result from the more conservative 100-year flood identified by the U.S. Geological Survey, (Berenbrock and Kjelstrom 1998) (Figure 4-9 of the EIS), which could result in a maximum flood depth of 1-foot in the northern half of INTEC. Within this flood contour at INTEC, there are radioactively and chemically (mixed-waste) contaminated soils. There are also contaminated soil piles protected by tarps from wind and precipitation, and contaminated soils exposed to erosion and water infiltration. Without mitigation, such as constructing berms to divert flooding, this area would be inundated. Though the area would be inundated, it is expected there would be no erosion and little transport of contaminates because of very low flow velocity. Infiltration would occur but would not be significantly greater than infiltration resulting from average annual precipitation over several years.

On January 18, 2001, DOE issued a floodplain determination, an estimate of the 100-year flood elevation, for RCRA permitting purposes at INTEC (Guyman 2001). The determination is based on the Flood Routing Analysis for a Failure of Mackay Dam (Koslow and Van Haaften 1986), as is the probable maximum probable flood described above. The RCRA determination, however, is based on a 100-year flow scenario, which involves the overtopping of Mackay Dam resulting in a flood elevation of 4,916 ft, whereas the maximum probable flow estimate results in a flood elevation of 4,917 ft at INTEC. The 4,916 ft elevation is consistent with the safety authorization basis for facilities at INTEC. See Section 4.8.1.3 of this EIS and response to comment summary IV.C (2).

References:

Berenbrock, C. and L. C. Kjelstrom, 1996, *Estimated 100-Year Peak Flows and Flow Volumes in the Big Lost River and Birch Creek at the Idaho National Engineering Laboratory*, Idaho, U.S. Geological Survey Water-Resources Investigation Report 96-4163, in cooperation with U.S. Department of Energy.

Berenbrock, C. and L. C. Kjelstrom, 1998, *Preliminary Water-Surface Elevations and Boundary of the 100-Year Peak Flow in the Big Lost River at the Idaho National Engineering and Environmental Laboratory*, Idaho, DOE/ID-22148, U.S. Geological Survey Water Resources Investigations Report 98-4065, Idaho Operations Office, Idaho Falls, Idaho.

Bhamidipaty, S., 1997, *Plan of Study Big Lost River Diversion System*, Department of the Army, Walla Walla District, Corps of Engineers, Walla Walla, Washington, June 17.

Guyman, R. H., 2001, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho, letter to K. B. Kelly, State of Idaho, Department of Environmental Quality, Boise, Idaho, "response to Department of Environmental Quality Request for Additional Floodplain Information for the Idaho National Engineering and Environmental Laboratory," January 18.

Koslow, K. N. and D. H. Van Haaften, 1986, Flood Routing Analysis for a Failure of Mackay Dam, EGG-EP-7184, EG&G Idaho, Inc., Idaho Falls, Idaho, June.

LMITCO (Lockheed Martin Idaho Technologies Company), 1998, *LMITCO Internal Report, Big Lost River Diversion Dike Foundation Investigation*, INEEL/INT-98-0090, Idaho Falls, Idaho, February.

Ostenaa, D. A., D. R. Levish, R. E. Klinger, and D. R. H. O'Connell, 1999, *Phase 2 Paleohydrolgic and Geomorphic Studies for the Assessment of Flood Risk for the Idaho National*

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Engineering and Environmental Laboratory, Idaho, Report 99-7, Geophysics, Paleohydrology, and Seismotechonics Group, Technical Service Center, Bureau of Reclamation, Denver, Colorado, September 16.

VIII.C (6)

Comment - A commentor cites the Draft EIS Summary, Section 7.4, discussion of cumulative impacts to water, and asks that the projected increase in plutonium concentrations be explained.

Response - Section 5.2.14 of this EIS discusses groundwater impacts for accident conditions for the various waste processing alternatives. The accident analysis considers the increase in groundwater contaminant concentrations due to the initiating event (e.g., material released from a full mixed transuranic waste/SBW tank at failure) plus the historical concentrations due to past contamination of the vadose zone and aquifer. Key radionuclides, metals, and organic contaminants are considered in the analysis including total plutonium. By including historical concentrations of contaminants in the analysis, the groundwater impacts from past waste practices such as the use of injection wells and leaks from valves and piping associated with the underground Tank Farm are considered. The apparent increase in plutonium concentrations in the aquifer is a projected value based on modeling of the plume that considers injection well contaminants in the aquifer and the contribution from contaminated soils. However, the modeling predicted concentrations are directly beneath the spills and/or release, so bounding environmental impacts can be presented. Modeling in the Remedial Investigation/Baseline Risk Assessment for CERCLA Waste Area Group 3 shows that plutonium could result in concentrations that would exceed EPA drinking water standards, if no remediation of the INTEC Tank Farm soils takes place.

VIII.C (7)

Comment - A commentor requests the location of the hypothetical well used in calculating the maximally exposed individual dose, shown on page S-55 (left column) in the Draft EIS, in relation to the INTEC Tank Farm.

Response - The maximally exposed individual is assumed to be a farmer who takes up residency within the existing INTEC facility fence line, about 100 meters from the Tank Farm. This would occur after 2095, when it is assumed for modeling purposes that DOE would lose institutional control of INTEC and the farmer has no knowledge of groundwater contamination in this area. Since the farmer would require a source of water for domestic and agricultural needs, it is assumed he would drill a well into the aquifer directly below the existing INTEC Tank Farm. Under this scenario, this farmer would proceed to drink 2 liters of contaminated water per day for 30 years. This analysis appears in Appendix C.9 of this EIS.

VIII.C (8)

Comment - A commentor supports the State of Idaho's concern for prevention of further contamination of the aquifer and supports appropriate treatment of all HLW requiring disposal in a geologic repository outside of Idaho.

Response - The Snake River Plain Aquifer is a resource that must be protected. That is among the reasons why the State of Idaho scrutinizes DOE activities at the INEEL and has actively overseen waste treatment and disposal activities. In the case of HLW, the Settlement Agreement/Consent Order and subsequent regulatory Consent Orders are the vehicles for ensuring that the liquid stored in non-compliant underground tanks no longer poses a threat to the aquifer. Further, the Settlement Agreement/Consent Order was crafted so that all of the liquid in the underground tanks and calcine in the bin sets would be prepared for disposal so these wastes pose less risk to the environment and can be transported to an interim storage or disposal facility outside of Idaho. The State of Idaho agrees with the commentor's contention that INEEL, positioned over the Snake River Plain Aquifer, is not an appropriate location for long-term storage or disposal of this waste.

VIII.C (9)

Comment - A commentor recommends that the effects of organic decay and colloid formation on the mobilization of plutonium and other actinides be addressed in the EIS.

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Response - The effects of facilitated transport mechanisms such as organic complexing agents and colloid formation are difficult to predict. Although not directly evaluated in this EIS, these mechanisms are indirectly addressed by evaluating smaller distribution coefficients (K_ds) in the sensitivity analyses described in Appendix C.9 of this EIS. A smaller distribution coefficient has the same effect on the modeling results as facilitated transport mechanisms, namely increased contaminant solubility and mobility.

VIII.E Geology Seismic Risk

VIII.E (1)

Comment - A commentor states that all waste should be removed from INEEL because the site is located in a seismically active area on top of a large aquifer.

Response - As stated in Section 4.6.3 of this EIS, the Eastern Snake River Plain has a relatively low rate seismic activity, compared to the surrounding basin and range. Potential seismic hazards from earthquakes at the INEEL consist of ground shaking and surface deformation, but avalanches, mudslides, landslides, and soil liquefaction are not likely to occur because the onsite geologic conditions would not likely support these events. Based on seismic history of the Eastern Snake River Plain, earthquakes greater than a moment magnitude of 5.5 is not likely to occur, but the environmental impacts from a strong earthquake have nevertheless been evaluated and are presented in Section 5.2.14 of this EIS. The EIS discloses environmental impacts to the aquifer from treatment alternatives considered, including No Action.

VIII.G Health and Safety

VIII.G (1)

Comment - Commentors express concern that waste and other by-products are finding their way into food and water supplies and may result in cancer and other sickness to people in Idaho, and threaten their longevity and future generations.

Response - Models used to determine the environmental impacts to public health due to INEEL operations, such as the alternatives analyzed in this EIS, include the effects of consumption of food and water. Prior to 2095, when it is assumed for modeling purposes that DOE retains institutional control of the site, consumption by an individual living at the site boundary is assumed to occur. After 2095, consumption would occur within the INTEC fence line, including food grown in the area and water taken from a well drilled there. The results of these analyses through 2095 indicate that under normal operating conditions, none of the alternatives would result in health and safety impacts that would exceed regulatory limits designed to ensure public safety. Furthermore, except for the No Action and Continued Current Operations alternatives, long-term environmental impacts (up to 10,000 years) from residual radiological contamination would not exceed regulatory limits to the environment or members of the public. The No Action Alternative and disposal of Class A or C-type grout in a new Low Activity Waste Disposal Facility would exceed regulatory limits for nonradiological contamination (cadmium).

DOE has also evaluated potential accidents associated with the alternatives that could, if they were to occur, result in significant environmental impacts to the public. The probability of such an occurrence makes it unlikely, and when the risk is calculated (consequence multiplied by chance of occurrence), the environmental impacts are considered small. Because mixed transuranic waste/SBW and mixed HLW calcine would remain on site at the INTEC facility under the No Action and Continued Current Operations alternatives, these alternatives present the highest long-term risk to the public and the environment, particularly in the areas of facility degradation over time and potential for accidents, particularly those induced by natural phenomena.

Partly in response to concerns such as those expressed by the commentor, DOE has in place a routine environmental surveillance program that regularly monitors air emissions and actual environmental impacts to the aquifer, wildlife, and local vegetation. Results are reported annually in a publicly available INEEL Annual Environmental Report. The State of Idaho also performs

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monitoring to independently verify the environmental surveillance data reported by DOE and in some cases collects supplemental samples to attain a higher level of assurance. This information is made publicly available on a quarterly basis and a report comparing State of Idaho and DOE data is issued annually. The commentors can expect that such programs would be in place during the period of time covered by the waste processing alternatives evaluated in this EIS. Further, facility disposition alternatives would be implemented based on established levels of acceptable risk to public health and the environment. See responses to comment summaries in VIII.B and VIII.C for additional responses to concerns regarding air emissions and environmental impacts to the aquifer respectively, as well as Chapter 4 and Chapter 5 of this EIS.

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